LIBRARY

MACHINE DESIGN

September 19

621.11
P-B
v.2 pt.3

Part3

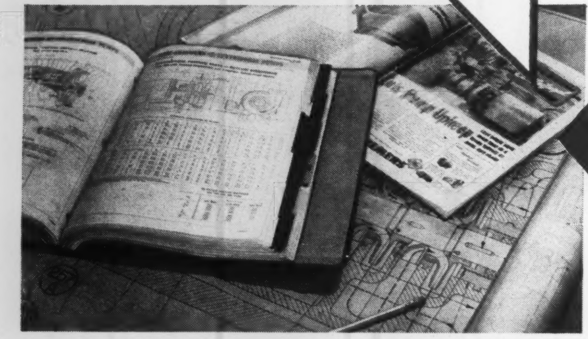
SILICONES

Contents, Page 3

TECHNOLOGY

ALLIS-CHALMERS PUMPS for Designers

3 Ways to Save



1

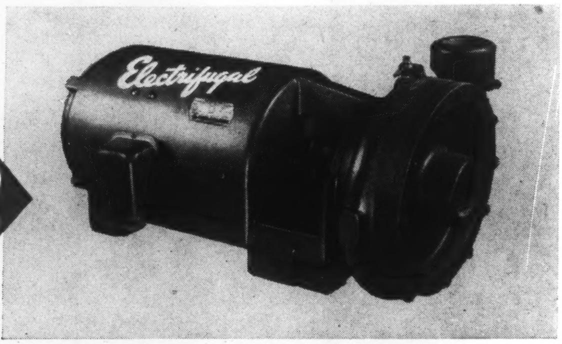
SAVE ENGINEERING TIME

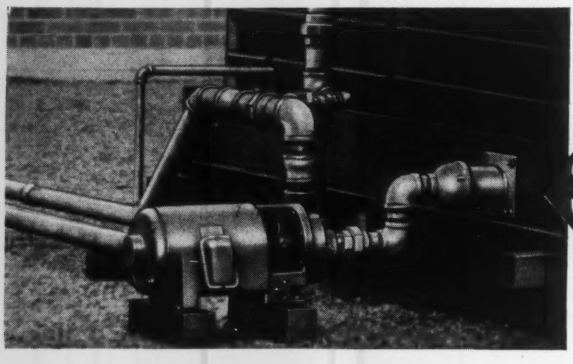
Allis-Chalmers representative will sit down with you in the planning stage and help you design the best possible pump set-up at the lowest cost. A-C field engineers will save you much costly engineering work and *guarantee* the complete pump and motor unit.

2

SAVE—NO EXTRA PARTS TO BUY

Designed as a complete, compact unit, Allis-Chalmers close-coupled pumps don't require extras — such as couplings, bases or shims. The pumps come as units ready to hook up and run!





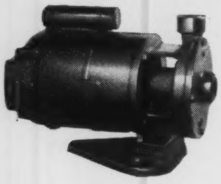
3

SAVE ON INSTALLATION TIME

Bolt it down, hook up the line and piping, and your Allis-Chalmers pump is ready to go. There's no alignment problem. Correct installation is a big factor in pump performance and the A-C engineer will advise you at this point.

For more information about Allis-Chalmers designers' pumps, write for bulletins 52B6140, 52B7529, 52B6083 or 52B6975.

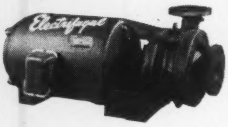
ALLIS-CHALMERS, Milwaukee 1, Wisconsin



FHP PACKAGE PUMP

Standard with mechanical seal. Widely used and accepted for air conditioning and refrigeration.

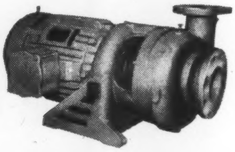
Bulletin 52B7529



***ELECTRIFUGAL* PUMP**

A close-coupled pump with either conventional packing or mechanical seal.

Bulletin 52B6140



SUPPORTING ADAPTER PUMP

Flange motor and pump on sturdy supporting adapter. With conventional packing or mechanical seal.

Bulletin 52B6083

VERTICAL MOUNTED PUMP

Mechanical seal or sealless units with choice of submerged or sidewall mounting.

Bulletin 52B6975

Electrifugal is an Allis-Chalmers trademark.

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

A-4228

B-13

THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

SEPTEMBER 1954
Vol. 26—No. 9

EDITORIAL STAFF

COLIN CARMICHAEL, *Editor*

BENJAMIN L. HUMMEL, *Associate Editor*

ROBERT L. STEDFELD, *Associate Editor*

LEO F. SPECTOR, *Associate Editor*

KEITH A. CARLSON, *Assistant Editor*

ROBERT C. RODGERS, *Assistant Editor*

JOHN B. HOLT, *Assistant Editor*

LAURENCE D. SHERGALIS, *Assistant Editor*

JANE H. SMITH, *Assistant Editor*

FRANK H. BURGESS, *Art Editor*

ROGER W. BOLZ, *Contributing Editor*

New York ....B. K. PRICE
L. E. BROWNE, SAMUEL W. BAKER
Detroit ....FLOYD G. LAWRENCE
Chicago ....ERLE F. ROSS
Pittsburgh ....ROBERT M. LOVE
Washington ....E. C. KREUTZBERG
London ....VINCENT DELPORT

REGULAR DEPARTMENTS

Over the Board 4
Index 7
Engineering News Roundup 12
Meetings and Expositions 50
Men of Machines 55
Helpful Literature 227
New Parts and Materials 232
Engineering Dept. Equipment .. 286
Stress Relief 296
The Engineer's Library 301
Noteworthy Patents 306
New Machines 312

USE POSTAGE-FREE CARDS FOR:

INFORMATION
on products advertised 33

EXTRA COPIES
of editorial articles 211

ADDITIONAL DATA
on new products and methods . 227

Challenge for Tomorrow .... ***Editorial*** 147

Engineering progress in the past twenty-five years has been rapid — but the next quarter century points toward even bigger accomplishments

Industrial and Engineering Design .... ***By Peter Muller-Munk*** 148

An industrial designer gives his views on successful co-ordination of the two operations

Scanning the Field for Ideas 152

Floating-hub design — sintered-carbide shafts — dual-flow tubing — bolt preloading — accurate welding positioning — fluid-piston bearings

Designing with Textured Metals .... ***By Joseph J. Clement*** 156

Attractive appearance and structural strength are two useful design characteristics of "rigidized" metals

Electrical Noise Suppression .... ***By M. B. Ewalt*** 161

Fundamental concepts in and design methods for combating radio interference

Systematic Mechanism Design .... ***By J. Denavit and R. S. Hartenberg*** 167

Part 1 — Symbolic notation plus a catalog of basic mechanisms equals a new method for deducing practical mechanisms

New Developments in Silicones .... ***By T. A. Kauppi*** 176

A review of current design possibilities in this unusual class of engineering materials

Design for Riveting .... ***By Roger W. Bolz*** 191

Production and Design — Small rivets and their selection

Planning Machine Series .... ***By Paolo Tedeschi*** 195

Part 3 — Specific attack for planning hydraulic turbomachines

Pumps and Motors .... ***By Reiner J. Auman*** 209

Data Sheet — Charts for simplifying design of positive-displacement types

Applying the Magnetic Amplifier .... ***By J. J. W. Brown*** 214

Characteristics and uses for control applications

Plastic Laminates .... ***By Norman A. Skow*** 217

Electrical insulating properties of thermosetting types

Mechanical Fasteners .... ***By W. C. Stewart*** 220

Today's trends in selection and use of fasteners

Contemporary Design

Fishing reel 160
Drilling machine 166
Plating barrel 175
Saw-drill 190
Balancing machine 194
Air conditioner-furnace 208

Over the Board

Happy Birthday to Us

We'd like to take a short "time out"—and hope you will join us—for a chorus of "Happy Birthday to Us." This month is a notable one in MACHINE DESIGN's history since it marks our 25th anniversary. Starting in September, 1929, MACHINE DESIGN was the first publication specifically for design engineers.

The first months after it appeared, the Depression hit. Although the economic climate was not of the best, the new youngster managed to hang on and even to grow. A major war and a "police action" haven't stopped this growth and now, at a mature 25 years of age, we're happy to report that your journal is sound, healthy, and ready to serve you even better than in the past.

A lot of changes have marked these 25 years. At our recent bithday party we counted noses and found that the staff has grown from 8 to over 30 people. But four members of the original MACHINE DESIGN staff are still with us. Cutting our birthday cake (from left to right) they are: Frank Burgess, art editor; Mary Callahan, advertising service manager; Howard Dreyer, western manager; and Harold Veith, central western manager.

This Month's Cover

Like a chameleon, the silicone (Page 176) seems able to camouflage itself by changing its physical chacteristics—silicones can be made as oils, plastics, rubbers, paints, and many other forms. But several properties—high and low temperature resistance, dielectric strength, arc resistance, and moisture resistance — are common to almost all forms of silicones. These common characteristics have formed the basis for George Farnsworth's striking and rather imaginative cover.

MACHINE DESIGN
September 19
. . SILICONES

MACHINE DESIGN

Penton Building, Cleveland 13, Ohio
Main 1-8260

BUSINESS STAFF

ROBERT L. HARTFORD
Business Manager

Advertising

New York 17 ....60 East 42nd St.
Russell H. Smith, Alan C. Bugbee
James A. Stangarone
Murray Hill 2-2581

Cleveland 13 ....Penton Building
Harold B. Veith, Jack W. Walton
Main 1-8260

Chicago, Ill. ....520 North Michigan Ave.
Howard H. Dreyer, Robert Z. Chew
Whitehall 4-1234

Los Angeles 48 .. 6262 Commodore Sloat Drive
F. J. Fuller
Webster 1-6865

San Francisco 4 .... 57 Post Street
F. J. Fuller, Robert W. Walker Co.
Sutter 1-5568

Griffin, Ga. ....331 South Twelfth St.
Fred J. Allen
Griffin 7854

London, S.W.1 ....2 Caxton St., Westminster

Mary L. Callahan
Advertising Service Manager

Richard J. Strnad
Production Manager

Betty Root, *Staff Assistant*

Research & Promotion

Richard A. Templeton, *Research Manager*
George J. Auner, *Statistician*
Virginia R. Homad, *Staff Assistant*

Circulation

Jack C. Gernhard, *Manager*
Pauline J. Herndon, Josephine Kozak
Betty Lou Suglio
Amy Lombardo, *Directory & List Dept.*

Published by
THE PENTON PUBLISHING COMPANY
G. O. HAYS ....*President and Treasurer*
R. C. JAENKE ....*Executive Vice President*
F. G. STEINEBACH ....*Vice President and Secy.*
F. O. RICE ....*Vice President*
J. P. LIPKA ....*Asst. Secy. and Asst. Treas.*

Also Publisher of
STEEL, FOUNDRY, NEW EQUIPMENT DIGEST, AUTOMATION

Published on the seventh of each month. Subscription in the United States, possessions, and Canada: One year $10. Single copies, $1.00. Other countries one year, $20. Copyright 1954 by The Penton Publishing Company. Acceptance under Section 34.64 P. L. and R. authorized.

BPA NBP

INDEX

Advertising and editorial content itemized for convenience when studying specific design problems

A

- Adhesives, Adv. 84
- Air conditioner-furnace, Edit. 208
- Aluminum and alloys, Edit. 30, 47; Adv. 235, 251, 253, 311, 330
- Amplifiers, magnetic, applying, Edit. 214

B

- Balancing machine, Edit. 194
- Balls, Adv. 55
- Bearings, ball, Edit. 236; Adv. 11, 32, 87, 123, 226, 239, 242, 344, 346
  - fluid piston, Edit. 155
  - miniature, Adv. 242
  - needle, Adv. 239, 269
  - rod-end, Edit. 249, 267; Adv. 332, 360
  - roller, Adv. 26, 87, 95, 101, 123, 143 225, 226, 239, 269, 324, 344
  - sleeve, Edit. 240, 249, 262; Adv. 17, 51, 123, 221, 294, 318, 336
- Bellows, Edit. 242; Adv. 77, 138
- Belts, transmission, Adv. 98, 324, 350
- Bonding metals, Edit. 271
- Books, Edit. 301; Adv. 61, 125, 281, 346, 349, 354, 357
- Brakes, Edit. 232; Adv. 5, 337
- Brass (see copper and alloys)
- Bronze (see copper and alloys)
- Brushes, commutator, Adv. 256, 306
- Bushings, Adv. 294, 336, 351
  - ball, Adv. 318

C

- Carbon and graphite parts, Adv. 74, 256, 297, 347
- Casters, floating hub, Edit. 152
- Castings, centrifugal, Adv. 142, 240, 290
  - investment, Adv. 142, 270, 278, 281, 301
  - light alloy, Adv. 141, 284
  - non-ferrous, Adv. 284
  - sand, Adv. 142
- Ceramics, Adv. 31
- Chain, conveyor, Adv. 123, 131
  - transmission, Adv. 80, 123, 125, 131, 293, 350
- Circuit breakers, Edit. 234
- Clamps, Adv. 25
- Classified ads, Adv. 360, 361
- Clutches, Edit. 232, 306; Adv. 93, 276, 293, 324, 358
- Coatings (see finishes)
- Coatings, protective, Edit. 279; Adv. 133, 141
- Commutators, Adv. 306
- Compressors, Edit. 15, 21; Adv. 59, 115
- Computers, Edit. 38
- Connectors, electric, Edit. 240, 268, 274, 281; Adv. 296, 355
- Contactors, Adv. 295
- Control systems, electric, Edit. 31; Adv. 49, 247, 248
  - hydraulic, Adv. 339, 354
- Controls, cable, Adv. 356
  - electric, Adv. 96, 140, 359, back cover
  - emergency, Edit. 308
  - pneumatic, Edit. 260
- Conveyors, Adv. 123
- Cooling system, Adv. 355
- Copper and alloys, Adv. 51, 272, 279, 282, 336, 366
- Corrosion-resistant alloys, Adv. 45, 124
- Counters, Adv. 69
- Couplings, shaft, Edit. 310; Adv. 22, 123, 293
- Cutting fluid system, Edit. 234
- Cylinders, hydraulic, Adv. 8, 9, 38, 85, 321, 346
  - pneumatic, Edit. 254; Adv. 8, 9, 38, 85, 321, 346

D

- Dowel pins, Adv. 313
- Drafting equipment, Edit. 286, 288, 290, 292; Adv. 348, 358, 359
- Drilling, Edit. 166
- Drives, adjustable speed, Adv. 78, 82, 96, 123, 245, 255, 345, inside back cover

E

- Electric equipment (see specific type)
- Electrical noise suppression, Edit. 161
- Engineering department (see Management or Drafting)
- Engines, Edit. 258; Adv. 68
- Expansion joints, Edit. 232
- Extrusion, Adv. 366

F

- Facilities, general, Adv. 134, 223, 252, 341, 363
- Fasteners, bolts, nuts and screws, Edit. 234, 250, 262; Adv. 28, 35, 47, 56, 58, 64, 88, 105, 126, 135, 241, 310, 314, 347, 356
  - insert, Adv. 40, 88
  - locking, Edit. 154; Adv. 100, 126, 260, 320
  - mechanical, changing trends, Edit. 220
  - pin, Adv. 313, 353
  - retaining rings, Edit. 232; Adv. 365
  - rivet, design for, Edit. 191
- Felt, Adv. 285, 340
- Filters, Adv. 137, 275, 298, 327
- Fittings, pipe, tube and hose, Edit. 232; Adv. 25, 99, 233
- Fixtures, Adv. 19
- Forging, Adv. 279, 311, 326
- Friction materials, Adv. 63, 328

G

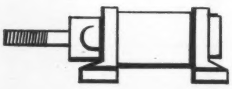
- Gages, pressure, etc., (see also Instruments)
- Gaskets, Adv. 60, 119
- Gears, Adv. 108, 136, 267, 268, 287, 296, 334, 354
- Generators, electric, Edit. 250; Adv. 49

H

- Hand tool, reciprocating or rotating, Edit. 190
- Heaters, Edit. 264; Adv. 304

(*Concluded on Page* 10)

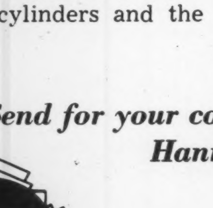
WHAT IS IT THAT MAKES ONE CYLINDER *BETTER* THAN ANOTHER?



When people set out to buy silverware, they accept without question the difference in price between sterling and plate. Without being silversmiths, they know that the price variance is justified by the intrinsic difference in quality, performance and life expectancy. This is equally true in the case of automobiles. Or in fine furniture. It's no less true in the case of cylinders.

There's a marked difference in cylinders, too. As in the case of many other products, it isn't always apparent to the naked eye. It's there, nonetheless, and over a period of time the difference makes itself known. If, on occasion, you have been quoted a higher price on Hanna cylinders than on competitive cylinders, you may have wondered what accounts for the difference. What exactly are the differences that make Hanna cylinders a better investment?

Well, for one thing, the tube of every Hanna H-P cylinder is centrifugally cast Meehanite (1-1/16″ av. thickness), accurately bored and honed for low friction and perfect oil seal. Cast Meehanite is used because it lends cylinder tubes greater dimensional stability and more stubborn resistance to external damage.

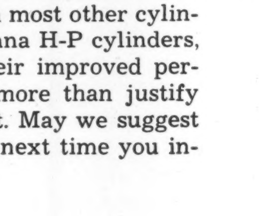


There's a pronounced difference, too, between the head of most cylinders and the Hanna cylinder head. In the Hanna product, large, metal-to-metal contact area between cylinder head and tube prevents cocking and assures squareness of mounting surfaces to the bore.

Hanna rod packings are designed for a more efficient seal and longer, trouble-free cylinder life. The spring-backed rod packings provide compensation for friction and wear.

The piston and rod of a Hanna cylinder are constructed of either a single piece of high carbon steel to assure concentricity and maximum strength, or assembled with shrink-fit welded construction and machined after assembly. In the latter case, ends are relieved to prevent wall scoring.

Even the assembly screws of a Hanna cylinder boast a feature found in few competitive cylinders. The heat-treated alloy socket head screws are closely spaced for maximum strength and countersunk into heads for a clean-cut appearance. Non-tie rod construction further enhances the streamlined design.



These, in the main, are the features that set Hanna cylinders apart from most other cylinders. Once you've used Hanna H-P cylinders, we're sure you'll agree their improved performance and longer life more than justify any small difference in cost. May we suggest that you bear this in mind next time you invest money in cylinders?

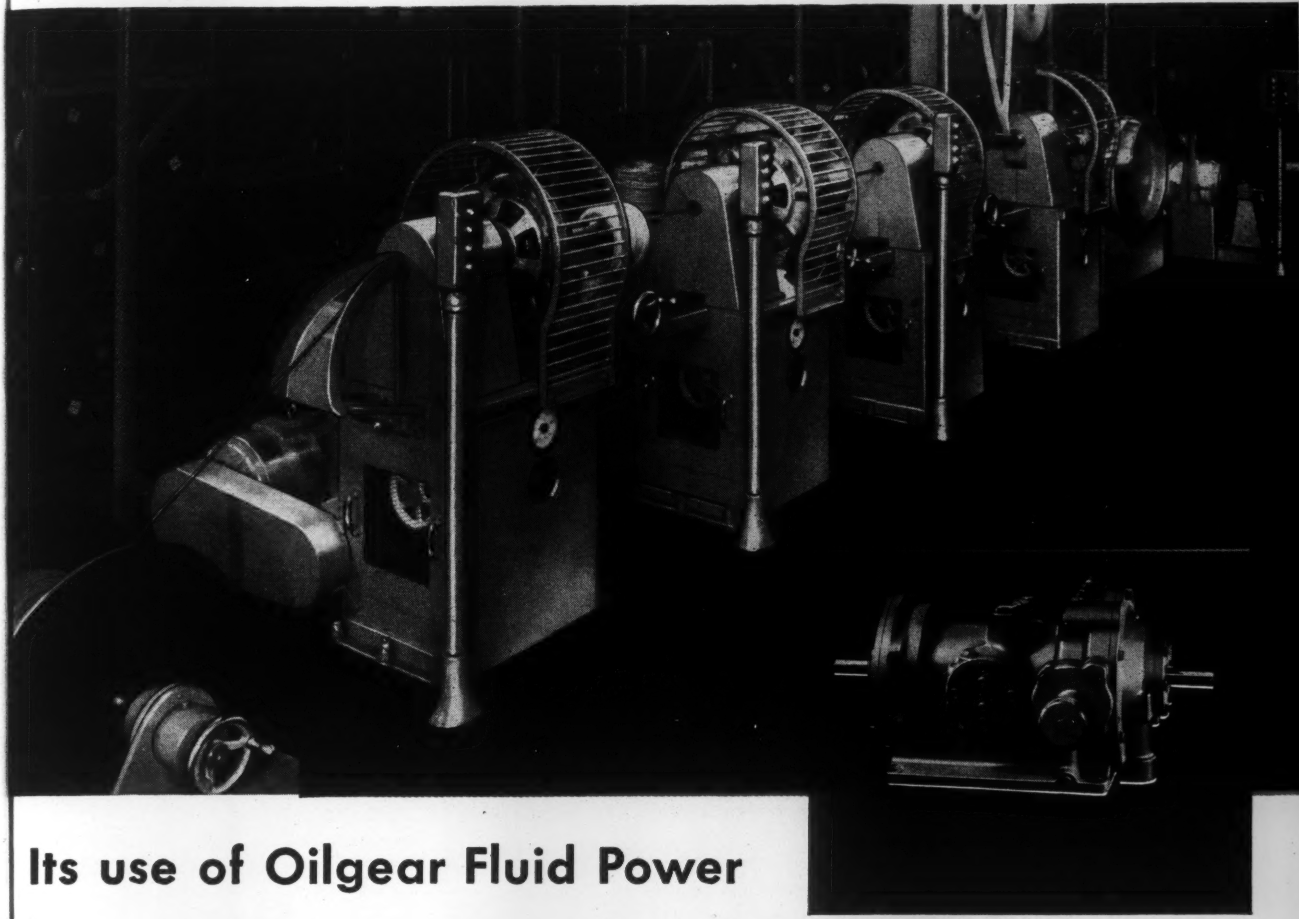
Send for your copy of the new Hanna H-P cylinder catalog

Hanna Engineering Works

1751 ELSTON AVENUE • CHICAGO 22, ILLINOIS

HYDRAULIC AND PNEUMATIC EQUIPMENT • CYLINDERS • VALVES • RIVETERS

MACHINE DESIGN AT WESTERN ELECTRIC



Its use of Oilgear Fluid Power

Western Electric Company, manufacturing unit of the Bell Telephone System, originates, designs and builds many of the special machines it uses in its own manufacturing processes. It also maintains unceasing pressure to improve upon machines already in operation, for optimum performance, for better product, for lower costs, for freedom from trouble.

Its use of Oilgear Fluid Power Drives and Transmissions has been increasing because, in the words of their engineers, Oilgear enables them among other things to synchronize many machine components easily and economically. A good example of all these points is the "short haul" video cable wrapping machine pictured above.

This machine was designed and built by the company's own men some years ago. For optimum performance, the speed of the heads should be easily and independently variable and the direction of rotation instantly changeable because the lay and pitch of the wrappings must be varied according to the requirements of the run. Moreover, the inside contour of the tube formed by the wrapping should be smooth and uniform so as to avoid setting up echo waves that interfere with transmission and vitiate signal strength.

Because of these requirements, a new drive was installed something over 4 years ago. A line shaft drives five Oilgear Fluid Power Transmissions, one at each machine head and the capstan.

The results were these: uniformity and control of tension are so good, the machine runs at 4 times its former machine speed; it is easy to vary speed and direction of rotation of each individual head; eccentric heads gave way to concentric heads, and supply spools are now loaded to full capacity instead of ¼th to ⅛th as before; the machine is stopped less frequently for loading. Maintenance on the former drive was involved and frequent—on the Oilgear equipment it has been simple and negligible.

There is some reason to suspect that Oilgear Fluid Power with its wide range of advantages may solve some of *your* machine design problems and make the results very pleasing and profitable. Why don't you really find out? THE OILGEAR COMPANY, 1568 West Pierce Street, Milwaukee 4, Wisconsin.

OILGEAR

OILGEAR

INDEX

(Concluded from Page 7)

Heat exchangers, Edit. 153
Heat resistant alloys, Adv. 124
Hose, metallic, Adv. 13, 77, 350
  nonmetallic, Edit. 267
Hydraulic equipment (see specific type)

I

Industrial design, Edit. 148
Inspection, Edit. 288; Adv. 319, 355
Instruments, Edit. 268, 290, 294; Adv. 86, 302, 305
Insulating properties, electrical, of plastic laminates, Edit. 217
Insulation, Edit. 234

J, K

Jacks, worm gear, Adv. 271
Keys, rubber, Edit. 306

L

Latches, Adv. 353
Lighting, Edit. 249
Lubricants, Adv. 27, 133, 141
Lubrication equipment, Adv. 20, 41, 237, 275

M

Machine series, planning, Edit. 195
Machines, (see specific type or process)
Maintenance equipment, Edit. 312
Magnesium and alloys, Edit. 48; Adv. 323
Magnetic amplifiers, applying, Edit. 214
Magnetos, Adv. 359
Management engineering, Edit. 12, 49
Materials handling, Edit. 312
Mechanisms Conference, Edit, 24; Adv. 238
Mechanism design, Edit. 167
Meetings, Edit. 24, 47, 50; Adv. 238
Metals, Edit. 244; Adv. 342
Metalworking, Edit. 312
Motors, electric:
  brakemotors, Edit. 252; Adv. 14, 102, 331
  fractional and integral hp, Adv. 1, 49, 62, 70, 96, 102, 107, 112, 116, 120, 145, 261, 277, 331, 333, 343, 345, 358
  gearmotors, Adv. 102, 123, 247, 334, 345
  subfractional, Adv. 1, 112, 347
Motors, hydraulic, Adv. 9, 114, 257
  hydraulic, positive-displacement design, Edit. 209
  pneumatic, Adv. 59

O, P

Office machines, Edit. 316
Packaging, Edit. 318
Packings, Adv. 48, 316
Photosensitive aluminum, Edit. 281
Pipe, Adv. 130, 233
Planning machine series, Edit. 195
Plant equipment, Edit. 318
Plastics plating barrel, Edit. 175
Plastics, Edit. 254, 256; Adv. 54, 71, 81, 242, 325
  fishing reel, Edit. 160
Plastics molding, Adv. 81, 328, 357
Plastic laminates, electrical insulating properties, Edit. 217
Plugs, Adv. 241, 244
Pneumatic equipment (see specific type)
Potentiometers, Edit. 267
Powder metallurgy, Adv. 94, 256, 288, 328, 338
Previews, Edit. 41
Processing equipment, Edit. 320
Pumps, Edit. 279, 320; Adv. inside front cover, 30, 59, 294, 308, 352
  hydraulic, Edit. 276; Adv. 9, 42, 114, 257
  hydraulic, positive displacement design, Edit. 209
  pneumatic, Edit. 264

R

Reducers, speed, Edit. 271, 284; Adv. 6, 247, 250, 324, 334, 352, 356
Relays, Edit. 258; Adv. 109, 274, 289
Rheostats, Adv. 127
Rubber, Adv. 111, 254, 259, 302
Rubber molding, Adv. 39, 129

S

Seals, Edit. 244; Adv. 263
  mechanical, Edit. 236; Adv. 2, 138, 229
Servos, Edit. 234
Shafts, Adv. 132
  flexible, Adv. 357
  sintered carbide, Edit. 153
Shapes, special, Adv. 280
Sheaves (see also pulleys), Adv. 98, 324
Silicones, Adv. 141
  new developments, Edit. 176
Slide assemblies, Edit. 244
Solenoids, Adv. 52
Spindles, Adv. 104
Springs, Adv. 66, 265, 348, 353, 354
Sprockets, Adv. 80, 125, 131, 293 350
Starters, motor, Adv. 50, 140
Steel, Edit. 46; Adv. 243, 363
Steel, stainless, Adv. 76, 89, 307
Switches, Edit, 236, 252, 256, 264; Adv. 50, 140, 289, 299, 349
Swivel joints, Adv. 37, 258
Systems, hydraulic, Adv. 303, 335, 351

T

Testing, Edit. 49; Adv. 302
Textured metals, Edit. 156
Thermostats, Edit. 49; Adv. 118, 322
Timers, Adv. 36, 139, 292
Tin and alloys, Adv. 346
Torque transmitter, Edit. 232
Transformers, Edit. 27; Adv. 49, 262
Transmissions, variable speed, Edit. 308; Adv. 9, 82, 312
Transistors, Edit. 27
Tubing, Edit. 234; Adv. 73, 130, 280, 286, 309
Turbines, Edit. 40

U, V

Universal joints, Edit. 310; Adv. 132, 244, 317
Valves, Edit. 267; Adv. 231, 233, 348, 352
  hydraulic, Edit. 249; Adv. 8, 9, 114, 249, 257
  pneumatic, Adv. 8, 146, 249

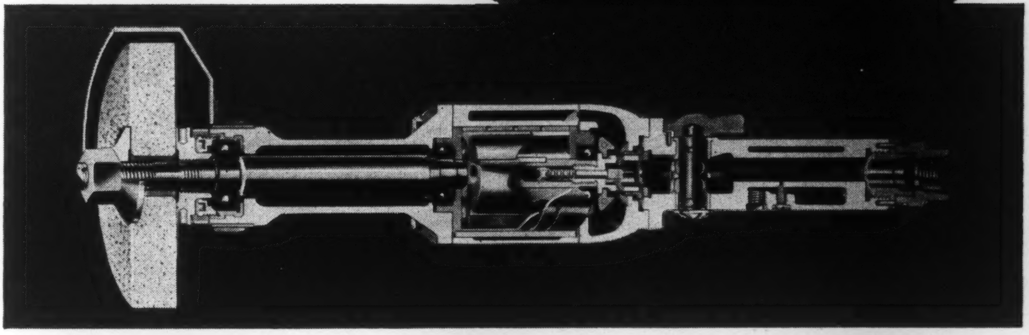
W

Wear resistant alloys, Adv. 124, 315, 343
Welding, Adv. 106, 134, 291
Weldments, Adv. 223, 264, 341
  parts alignment for, Edit. 154
Wind tunnel, design, Edit. 15
Wire and wire products, Edit. 274; Adv. 44, 66, 348, 353

MACHINE DESIGN is indexed in Industrial Arts and Engineering Index Service, both available in libraries, generally

With New Departures—
ROTOR GIVES UPKEEP THE "AIR"!

Rotor Tool Company design utilizes three New Departure ball bearings. Front bearing is wider to give greater surface on shaft and housing to withstand vibratory loads.



Holding the line against maintenance downtime! Three New Departures in the Rotor Tool air grinder need no adjustment . . . cut lubrication requirements to virtually zero.

These New Departure double-shielded bearings are protected from foreign matter. They have the high capacity to carry radial and thrust loads . . . to withstand the shocks of hard use and rough handling. At the same time, cool-running New Departure ball bearings maintain accurate alignment and assure maximum power at the grinding wheel.

You can build these advantages into *your* product, too. Talk with your New Departure engineer—*today!*

NOTHING ROLLS LIKE A BALL

NEW DEPARTURE

BALL BEARINGS

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT
Plants also in Meriden, Connecticut, and Sandusky, Ohio
In Canada: McKinnon Industries, Ltd., St. Catharines, Ontario

Engineering News Roundup

Salary Trends Show Engineering Progress

In 1929, the engineering graduate found slim pickings after the stock market collapse, but today he is making up for the lean years, according to Illinois Institute of Technology.

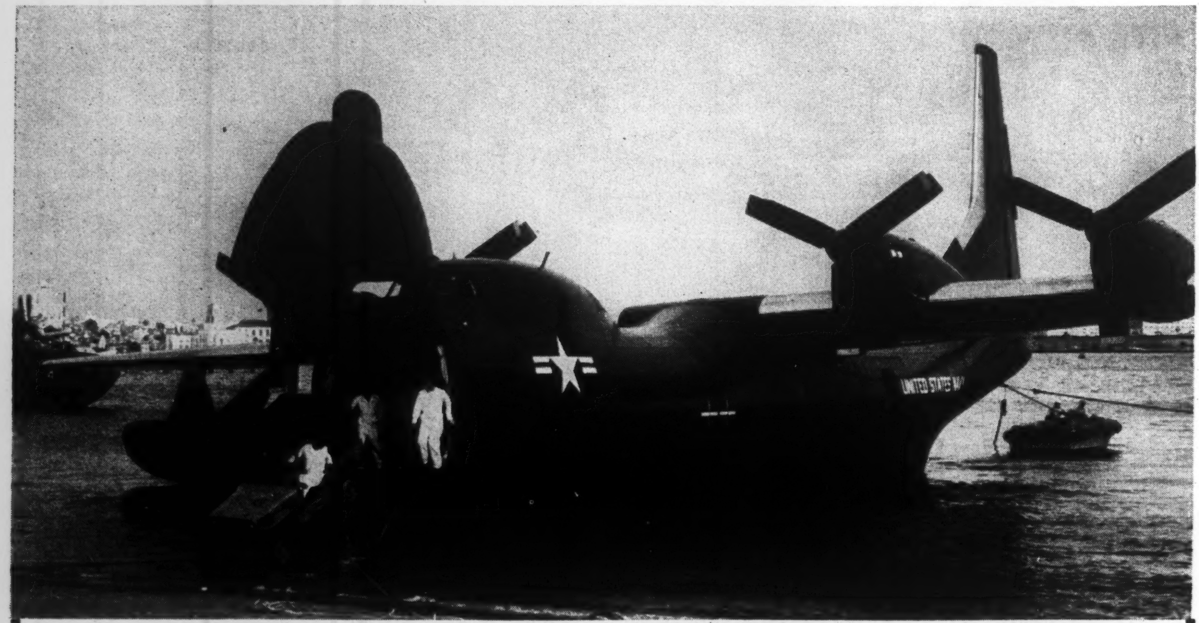
A study made of the economic status of IIT engineering graduates reveals that members of the Class of 1929 currently are earning a median salary of $10,000 to $11,000 a year.

Before the stock market crash, engineering graduates earned an average starting salary of approximately $115 a month. After the crash, the few engineering jobs that were available paid a mere pittance, the survey reports.

By 1934, engineering graduates were receiving an average starting salary of less than $100 a month. These same graduates today are earning a median salary of $8500 to $9000, according to results of the survey.

Conditions had improved slightly for the 1939 engineering graduates who started at an average monthly salary of $110. During the intervening years, their median salary rose to $8500-$9000 a year—four times their starting rate.

The advent of the technological age and the wartime boom boosted the beginning salary average to $193 in 1944. In the short span of 10 years their median salary in-



FLYING LST: A bow-loader version of the Navy's turboprop seaplane, the four-engined tradewind transport (MACHINE DESIGN, May, 1954, Page 192), built by Convair, can land guns, trucks, supplies or an assault company directly onto an enemy beach. For an assault operation, the plane lands in offshore waters and taxis to the beach. When the hull touches the sand, the bow opens upward, a ramp is dropped, and the loaded vehicles or troops debark directly onto the beach. To pull away, the pilot reverses the propellers and backs away creased to $7500-$8000, the survey revealed.

Salaries continued to spiral, and in 1949, IIT engineering graduates were offered starting salaries of $282 a month. Five years after graduation, their initial salary has been doubled in many instances with the class median at $5500-$6000.

Illinois Tech's June, 1954, graduates are earning an average starting salary of $363. All-time high was reached in 1953 when starting salaries averaged $373.

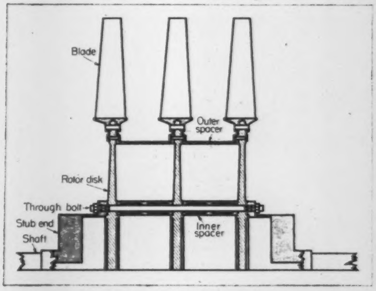
Wind Tunnel Design Challenges Engineers

Said to be the world's largest, the U. S. Air Force's new propulsion wind tunnel now under construction at Tullahoma, Tenn. will be arranged in two closed loops. One loop will provide transonic speeds, the other supersonic. Air speeds over 2500 mph are expected to be realized.

A common set of drive motors, being built by Westinghouse and totaling 216,000 horsepower, will power both tunnels. Drive speed will be 600 rpm. Two 83,000-horsepower synchronous motors, claimed to be the largest ever built, and two 25,000-horsepower wound-rotor motors comprise the drive set. It is expected that the motors can be started and the tunnel readied for tests in about 8 minutes.

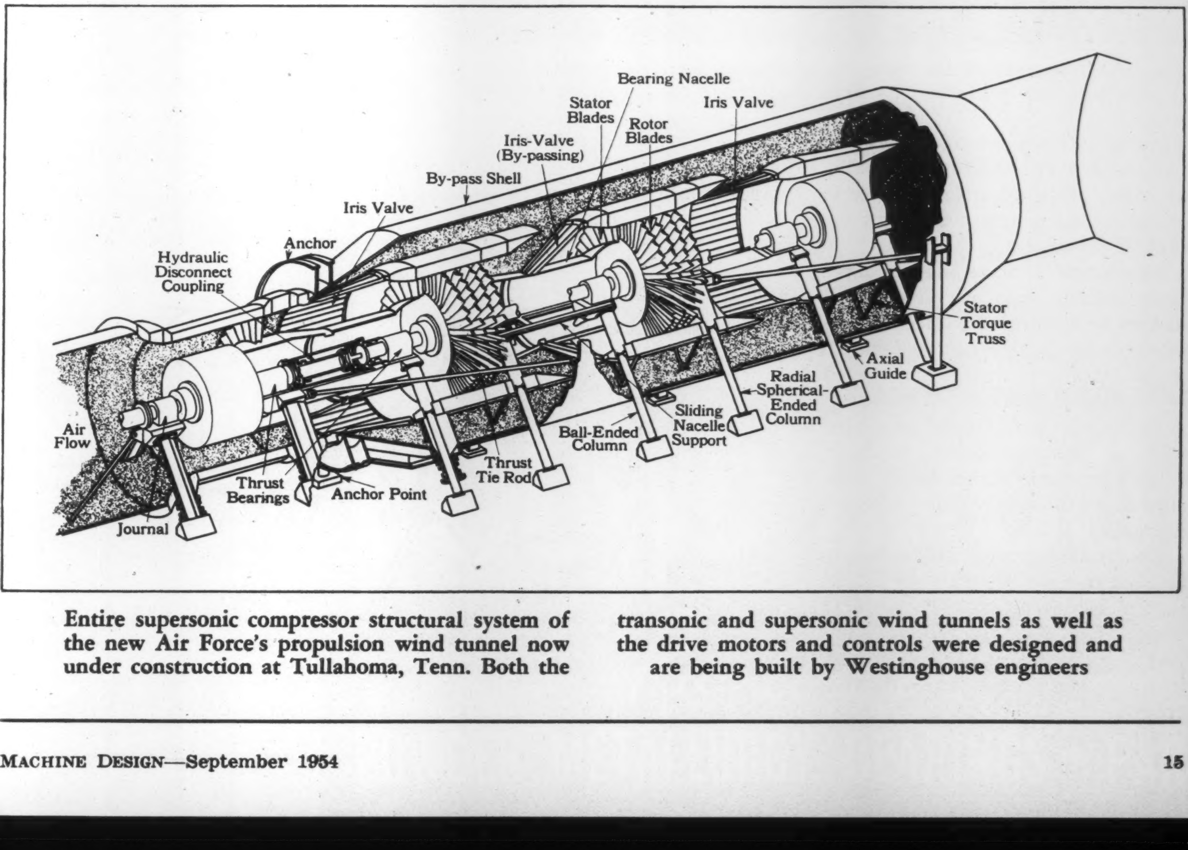
A few very large compressors are used in preference to many small compressors. Complexity of control of individual small compressors is said to outweigh their chief advantage of simplified design. In addition, fewer parts are required with large axial-flow compressors. They may also be mounted within the tunnel itself.

Physical size of the compressor system has been dictated by two factors. An 18-foot disk, it was found, was the largest that could be forged practically. To avoid the classic "boat built in a basement" situation, shipping requirements had to be met. Again, the 18-foot disk was found to be about the maximum size that could be shipped by rail from the East to the Westinghouse assembly plant in Sunnyvale, Calif.


Blade
Outer spacer
Rotor disk
Through bolt
Stub end
Shaft
Inner spacer

Cross section view of the transonic compressor rotor

High centrifugal loading of the


Bearing Nacelle
Stator Blades
Iris Valve
Rotor Blades
Iris-Valve (By-passing)
By-pass Shell
Iris Valve
Anchor
Hydraulic Disconnect Coupling
Stator Torque Truss
Axial Guide
Radial Spherical-Ended Column
Sliding Nacelle Support
Ball-Ended Column
Thrust Tie Rod
Air Flow
Thrust Bearings
Anchor Point
Journal

Entire supersonic compressor structural system of the new Air Force's propulsion wind tunnel now under construction at Tullahoma, Tenn. Both the transonic and supersonic wind tunnels as well as the drive motors and controls were designed and are being built by Westinghouse engineers

Engineering News Roundup

Salary Trends Show Engineering Progress

In 1929, the engineering graduate found slim pickings after the stock market collapse, but today he is making up for the lean years, according to Illinois Institute of Technology.

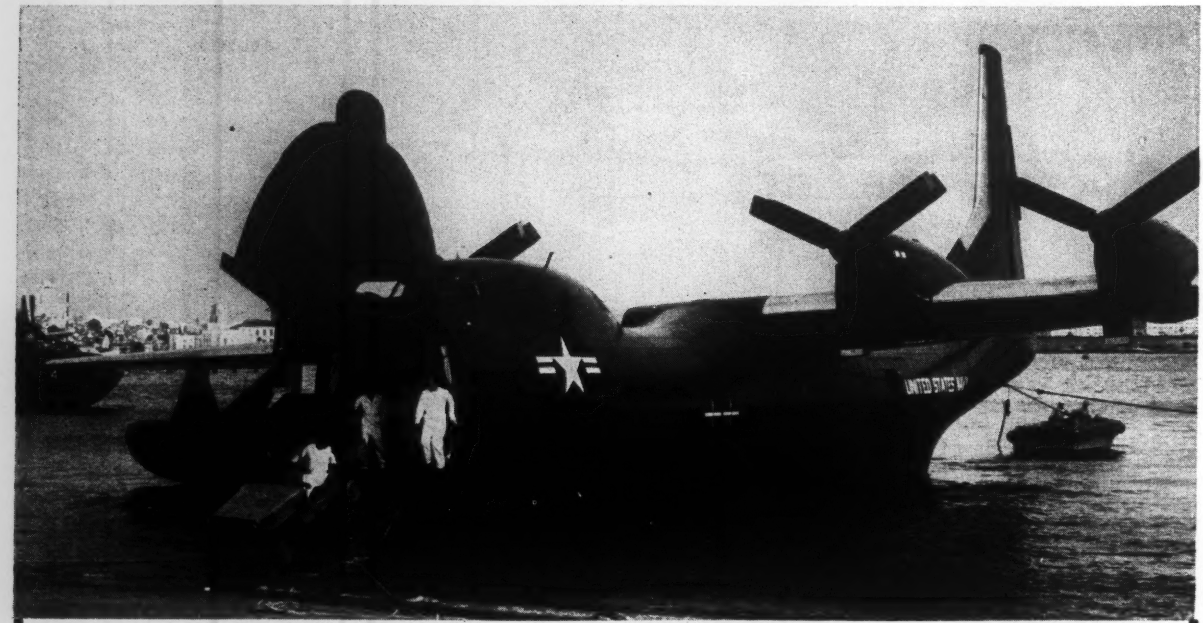
A study made of the economic status of IIT engineering graduates reveals that members of the Class of 1929 currently are earning a median salary of $10,000 to $11,000 a year.

Before the stock market crash, engineering graduates earned an average starting salary of approximately $115 a month. After the crash, the few engineering jobs that were available paid a mere pittance, the survey reports.

By 1934, engineering graduates were receiving an average starting salary of less than $100 a month. These same graduates today are earning a median salary of $8500 to $9000, according to results of the survey.

Conditions had improved slightly for the 1939 engineering graduates who started at an average monthly salary of $110. During the intervening years, their median salary rose to $8500-$9000 a year—four times their starting rate.

The advent of the technological age and the wartime boom boosted the beginning salary average to $193 in 1944. In the short span of 10 years their median salary in-



FLYING LST: A bow-loader version of the Navy's turboprop seaplane, the four-engined tradewind transport (MACHINE DESIGN, May, 1954, Page 192), built by Convair, can land guns, trucks, supplies or an assault company directly onto an enemy beach. For an assault operation, the plane lands in offshore waters and taxis to the beach. When the hull touches the sand, the bow opens upward, a ramp is dropped, and the loaded vehicles or troops debark directly onto the beach. To pull away, the pilot reverses the propellers and backs away creased to $7500-$8000, the survey revealed.

Salaries continued to spiral, and in 1949, IIT engineering graduates were offered starting salaries of $282 a month. Five years after graduation, their initial salary has been doubled in many instances with the class median at $5500-$6000.

Illinois Tech's June, 1954, graduates are earning an average starting salary of $363. All-time high was reached in 1953 when starting salaries averaged $373.

Wind Tunnel Design Challenges Engineers

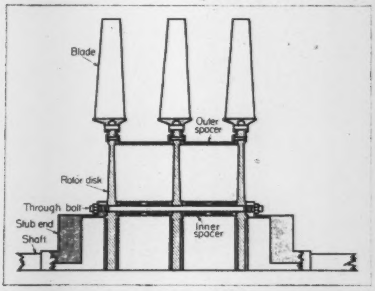
Said to be the world's largest, the U. S. Air Force's new propulsion wind tunnel now under construction at Tullahoma, Tenn. will be arranged in two closed loops. One loop will provide transonic speeds, the other supersonic. Air speeds over 2500 mph are expected to be realized.

A common set of drive motors, being built by Westinghouse and totaling 216,000 horsepower, will power both tunnels. Drive speed will be 600 rpm. Two 83,000-horsepower synchronous motors, claimed to be the largest ever built, and two 25,000-horsepower wound-rotor motors comprise the drive set. It is expected that the motors can be started and the tunnel readied for tests in about 8 minutes.

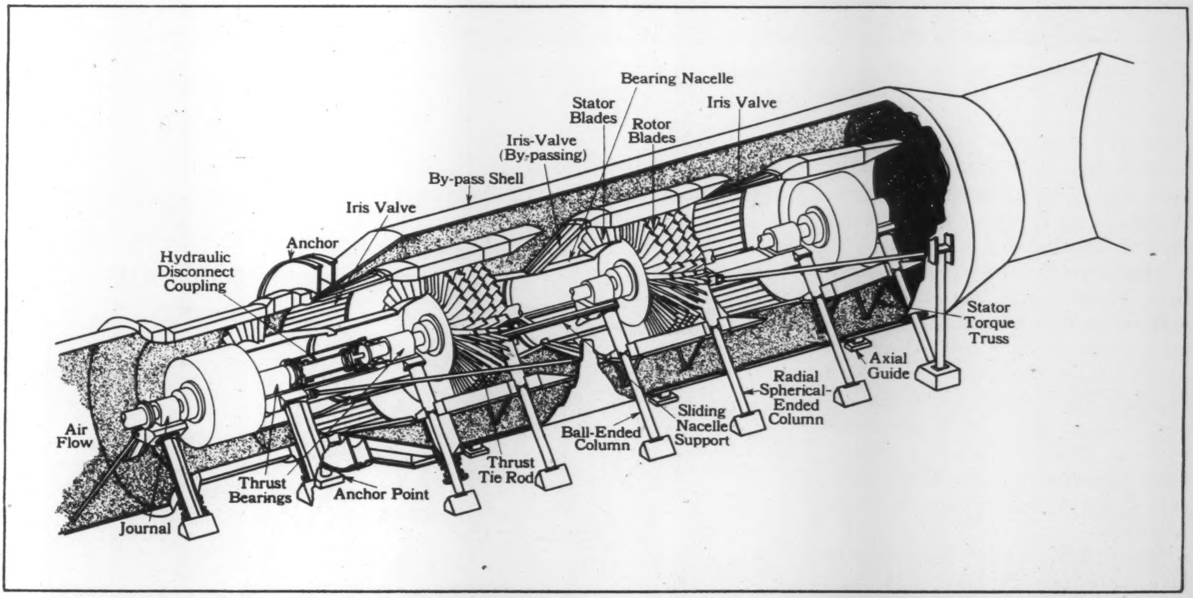
A few very large compressors are used in preference to many small compressors. Complexity of control of individual small compressors is said to outweigh their chief advantage of simplified design. In addition, fewer parts are required with large axial-flow compressors. They may also be mounted within the tunnel itself.

Physical size of the compressor system has been dictated by two factors. An 18-foot disk, it was found, was the largest that could be forged practically. To avoid the classic "boat built in a basement" situation, shipping requirements had to be met. Again, the 18-foot disk was found to be about the maximum size that could be shipped by rail from the East to the Westinghouse assembly plant in Sunnyvale, Calif.

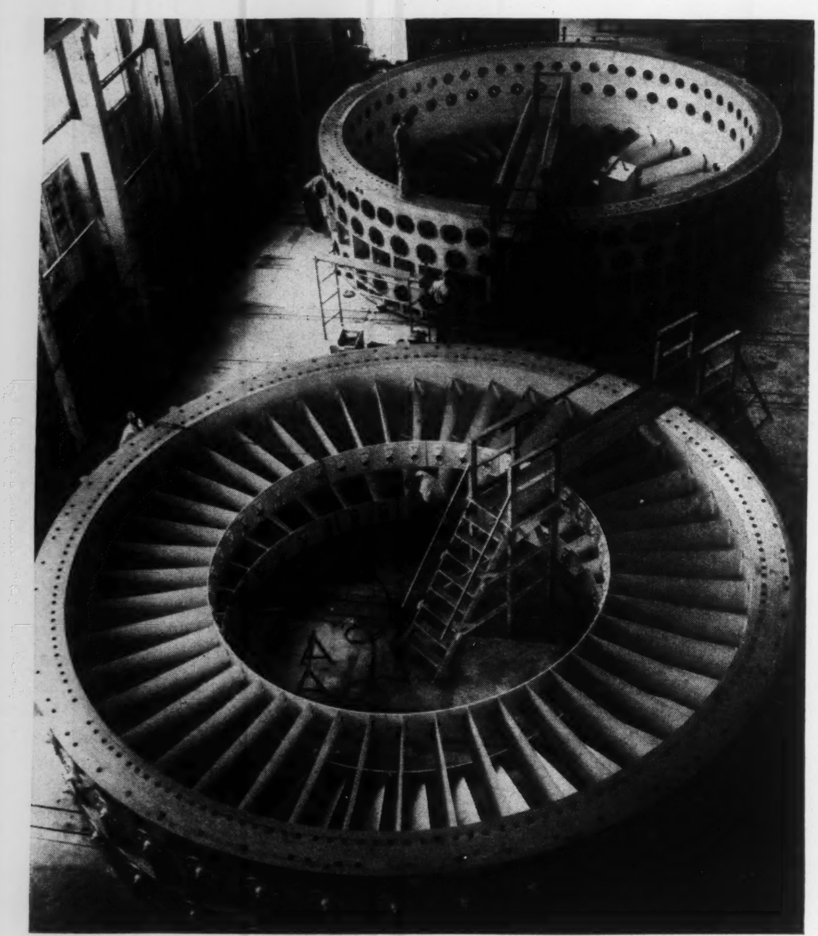
High centrifugal loading of the


Blade
Outer spacer
Rotor disk
Through bolt
Stub end
Shaft
Inner spacer

Cross section view of the transonic compressor rotor


Bearing Nacelle
Stator Blades
Iris Valve
Rotor Blades
Iris-Valve (By-passing)
By-pass Shell
Iris Valve
Anchor
Hydraulic Disconnect Coupling
Stator Torque Truss
Axial Guide
Radial Spherical-Ended Column
Sliding Nacelle Support
Ball-Ended Column
Thrust Tie Rod
Air Flow
Thrust Bearings
Anchor Point
Journal

Entire supersonic compressor structural system of the new Air Force's propulsion wind tunnel now under construction at Tullahoma, Tenn. Both the transonic and supersonic wind tunnels as well as the drive motors and controls were designed and are being built by Westinghouse engineers



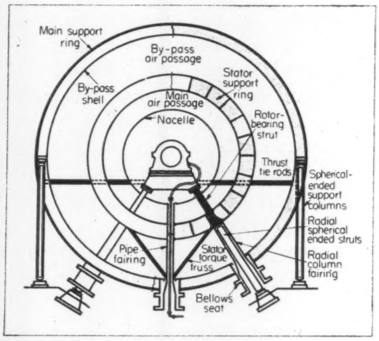
Two stator sections of the transonic compressor on the assembly floor. Controllable stator blades have been mounted in the foreground section

disks by the 6-foot-long blades has necessitated a bolted-together built-up rotor. This centrifugal force is calculated to be about 800 tons for each of the blades.

Synchronous drive motors have been chosen over variable speed motors because of the latter's complexity and greater cost. Variable speed motors, however, are needed for starting. Small volumes can be obtained with high pressures with a constant-speed machine. With a variable speed drive, pressure drops off with volume as speed decreases.

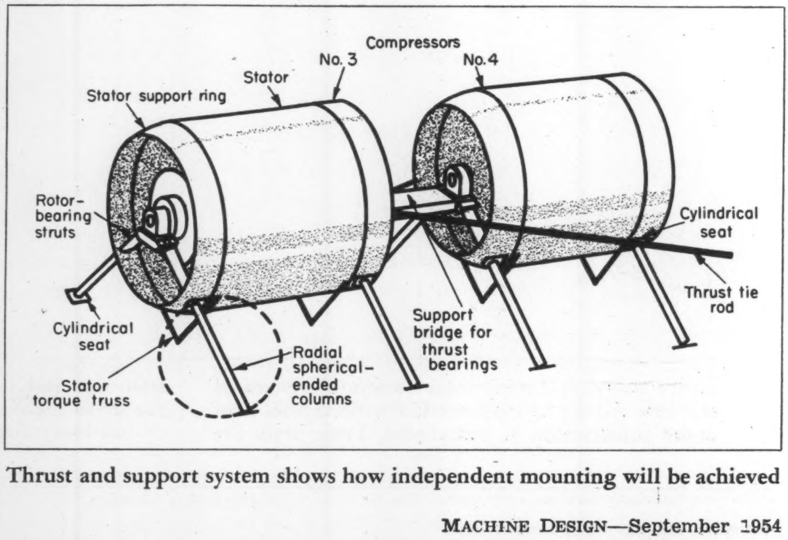
Controllable stator blades are to be used to meet the wide variations in flow requirements. These flows range from 7 to 13 million cubic feet per minute at the compressor inlets. Mach numbers ranging from 1.4 to 3.5 are produced in the test section. Each blade turns in specially designed bearings, and blade angle may be changed by plus and minus 15 degrees.

Bypassing of compressors and the direction of air from compressor to compressor is accomplished by giant iris valves up to 35 feet in diameter. Similar in operation to a camera aperture, they consist basically of 24 overlapping leaves, each approximately 17 feet long, 4 feet wide and 10 inches deep. They are hinged at the upstream end of one compressor and seated at the downstream end of the previous compressor. When open, the leaves form an approximately cylindrical duct leading from one compressor to the next. When closed, the air from the last operating compressor is directed to the bypass shell. Remotely operated flexible disconnect couplings have been designed for use with the supersonic compressor.


Main support ring
By-pass air passage
Stator support ring
By-pass shell
Main air passage
Nacelle
Rotor-bearing strut
Thrust tie rods
Spherical-ended support columns
Radial spherical ended struts
Pipe fairing
Stator torque truss
Radial column fairing
Bellows seat

Cross section of the supersonic compressor

To keep tunnel distortions from


Compressors
No. 3
No. 4
Stator
Stator support ring
Rotor-bearing struts
Cylindrical seat
Thrust tie rod
Cylindrical seat
Support bridge for thrust bearings
Radial spherical-ended columns
Stator torque truss

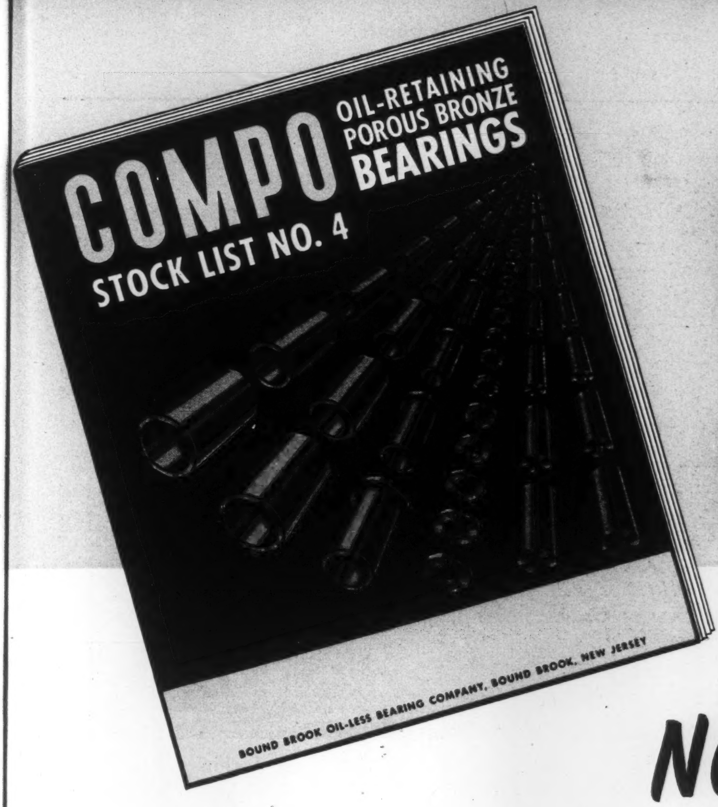
Thrust and support system shows how independent mounting will be achieved

NEW COMPO

OIL-RETAINING POROUS BRONZE

BEARING

STOCK LIST NOW AVAILABLE


COMPO OIL-RETAINING POROUS BRONZE BEARINGS

STOCK LIST NO. 4

BOUND BROOK OIL-LESS BEARING COMPANY, BOUND BROOK, NEW JERSEY

If you play a part in the design, production or maintenance of equipment using sintered bronze bearings, or if the job of purchasing bearings falls within your domain, you'll find a wealth of useful information within the 20 pages of the new Compo Oil-Retaining Porous Bronze Bearing Stock List No. 4. Bound Brook has compiled an easy-to-read list of the most popular stock sizes of bearings which are available for immediate shipment. In addition the Compo Stock List Brings you up-to-the-minute data on bearing application, installation, lubrication and machining. And here's another thought! When requesting your copy of the Compo Stock List why not have us send one to your supplier of bearing-using components or equipment? It may enable him to make savings beneficial to you both.

Write for a list of location of local warehouse stocks.

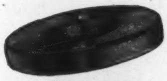
4

SLEEVE TYPE

FLANGE TYPE

BAR STOCK

CORED BAR STOCK


WASHERS

BOUND BROOK

BOUND BROOK OIL-LESS BEARING CO., EST. 1883, BOUND BROOK, N. J.

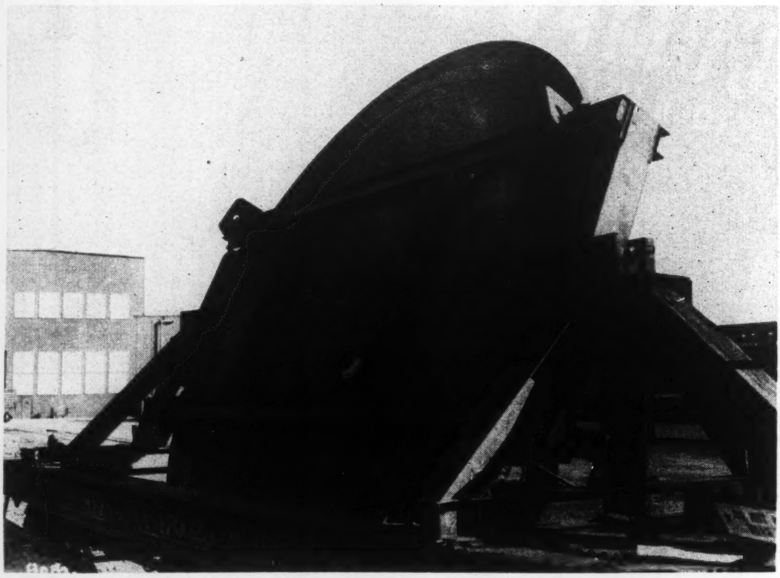
Pioneer in

POWDER METALLURGY BEARINGS + PARTS

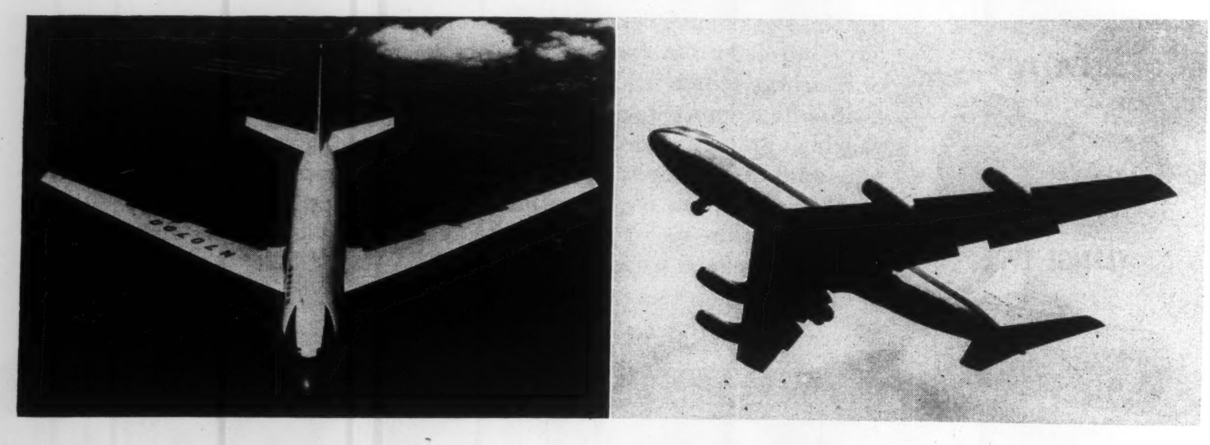
disturbing rotor alignment, the rotors will be supported independently of the bypass shell and tunnel structure. Weighing 11 million pounds, this freely supported supersonic compressor system will be maintained in accurate axial alignment, yet rigid enough to maintain high critical speeds.

Temperatures as high as 700 F are expected in the last compressor. Thermal expansion of the tunnel is restricted to the axial direction by guiding the supporting columns. These columns operate as large single ball bearings, allowing free movement of the stator during thermal expansion. Axial movement of as much as 5 inches is expected.

Lubrication problems caused by high temperatures and the problem of stopping the compressors after a test also highlighted the engineering development. Of particular interest to designers is the application of the detuning technique. To prevent dangerous resonant frequencies, rotor blades were designed to set their natural frequencies above lower multiples of the compressor operating speed. Westinghous reports this technique has never been used before in a project of this magnitude.



Shipping of the 18-foot diameter rotor disk from the forging plant in the east to the Westinghouse assembly plant in Sunnyvale, Calif. was accomplished by tilting it on a railroad flatcar

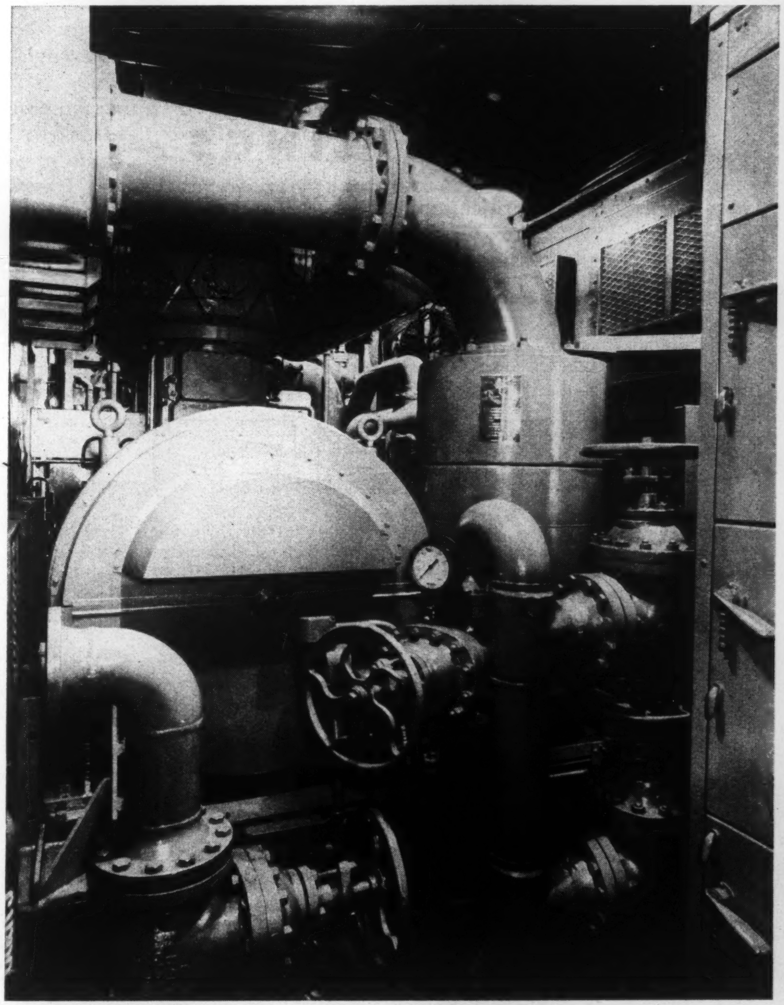


FIRST U. S. JET TRANSPORT made its initial flight recently near Seattle. Built by Boeing and designated the 707, this 190,000-pound airplane is designed to have a normal cruising speed of 550 mph. From 80 to 130 passengers will be carried at altitudes of between 30,000 and 40,000 feet. Four-segment landing flaps can be seen in the down position in the view at the left. Mounted in streamlined pods below the wings, the four Pratt and Whitney jet engines each develop 10,000 pounds of thrust. Two basic versions of the plane will be offered, the Stratatanker military tanker-transport, and the Stratoliner commercial airliner. They are expected to be capable of transcontinental nonstop flights in less than 5 hours and New York to London service of less than 7 hours

New Mobile Air Compressor Gets Quick Emergency Test

Said to be the first ever mounted in railroad cars, the first of a series of portable heavy-duty air compressors designed for the Navy was pressed into service on the day of its completion. Built by Clarke Bros. Co., the large mobile plant was rushed to a Naval shipyard to supply air while stationary compressors were being repaired.

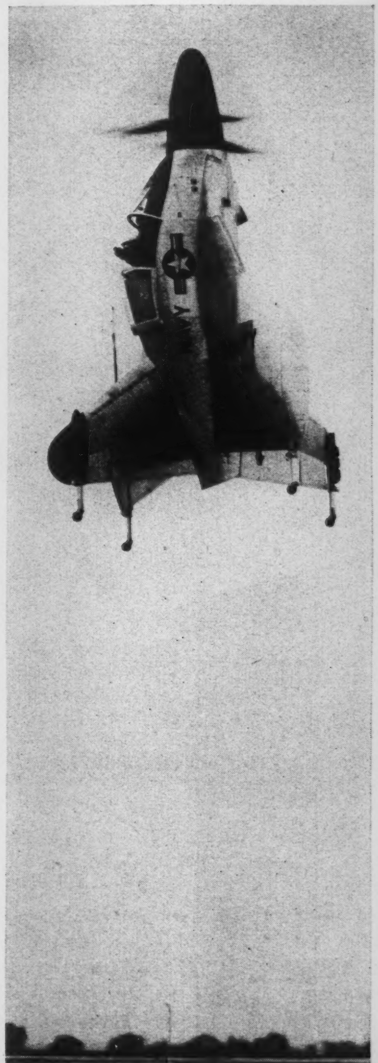
Equipped with a pair of heavy duty compressors, the unit is capable of supplying a volume of 5000 cfm at a pressure of 125 psi. Said to be the first time units of this size have been made portable, the equipment weighs a total of 138,000 pounds including 500-horsepower electric motors, switchboard, transformers and cooling and lubricating systems. All this fitted into a standard 60-foot railway box car.



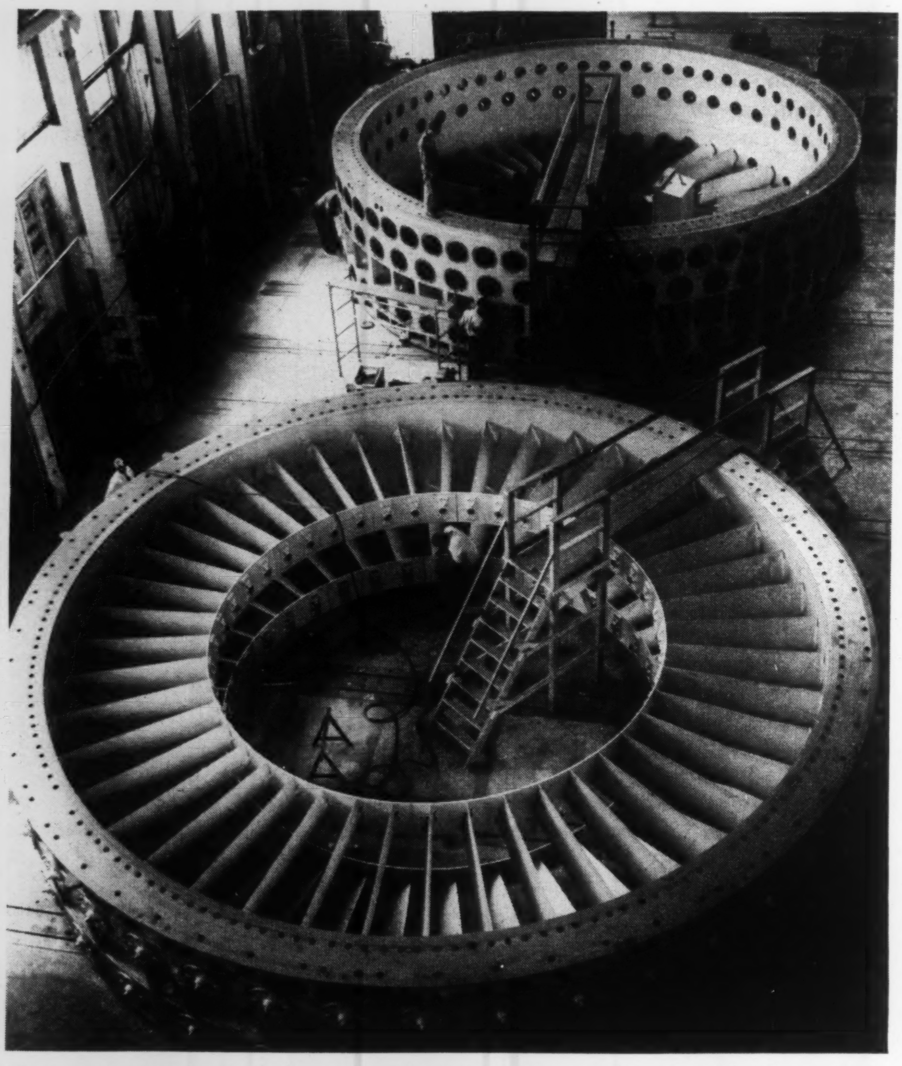
Inside view of the mobile compressor railway car shows how the equipment has been compactly installed yet is accessible for maintenance

Although labeled emergency units, the compressors are designed for continuous service. During its recent emergency operation, this first plant is reported to have worked a regular 8-hour shift daily for 42 days.

(*Continued on Page* 24)



IT FLIES: First free flight of Convair's vertical-rising airplane took place recently. This turbopowered aircraft (MACHINE DESIGN, May, 1954, page 194) was previously flown with a specially designed tethering rig. During this latest series of free flights, a maximum altitude of 150 feet was reached. Although the plane has been designed to fly conventionally after taking off, horizontal flight will not be attempted until after preliminary vertical tests have been completed



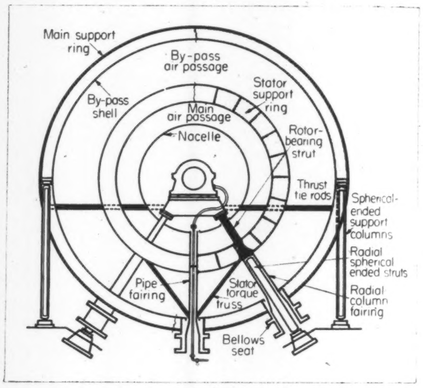
Two stator sections of the transonic compressor on the assembly floor. Controllable stator blades have been mounted in the foreground section

disks by the 6-foot-long blades has necessitated a bolted-together built-up rotor. This centrifugal force is calculated to be about 800 tons for each of the blades.

Synchronous drive motors have been chosen over variable speed motors because of the latter's complexity and greater cost. Variable speed motors, however, are needed for starting. Small volumes can be obtained with high pressures with a constant-speed machine. With a variable speed drive, pressure drops off with volume as speed decreases.

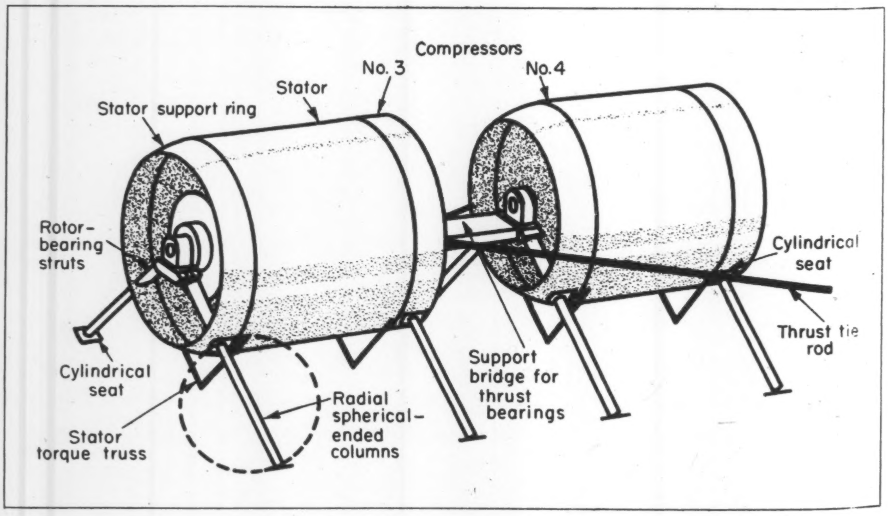
Controllable stator blades are to be used to meet the wide variations in flow requirements. These flows range from 7 to 13 million cubic feet per minute at the compressor inlets. Mach numbers ranging from 1.4 to 3.5 are produced in the test section. Each blade turns in specially designed bearings, and blade angle may be changed by plus and minus 15 degrees.

Bypassing of compressors and the direction of air from compressor to compressor is accomplished by giant iris valves up to 35 feet in diameter. Similar in operation to a camera aperture, they consist basically of 24 overlapping leaves, each approximately 17 feet long, 4 feet wide and 10 inches deep. They are hinged at the upstream end of one compressor and seated at the downstream end of the previous compressor. When open, the leaves form an approximately cylindrical duct leading from one compressor to the next. When closed, the air from the last operating compressor is directed to the bypass shell. Remotely operated flexible disconnect couplings have been designed for use with the supersonic compressor.

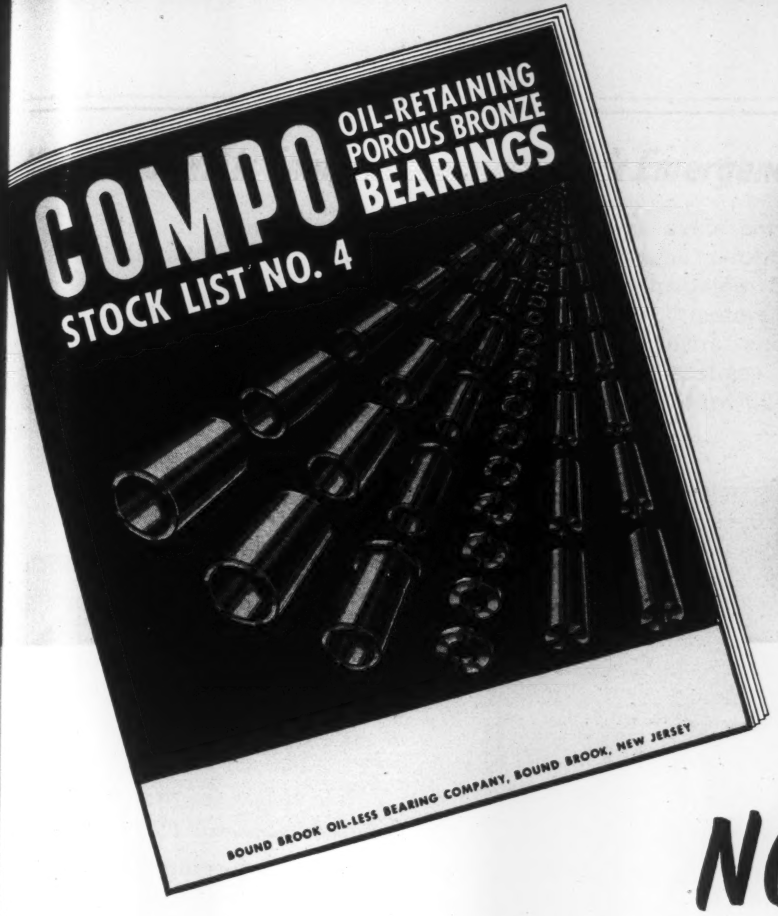

Main support ring
By-pass air passage
Stator support ring
By-pass shell
Main air passage
Nacelle
Rotor-bearing strut
Thrust tie rods
Spherical-ended support columns
Radial spherical ended struts
Radial column fairing
Pipe fairing
Stator torque truss
Bellows seat

Cross section of the supersonic compressor

To keep tunnel distortions from


Compressors
No. 3
No. 4
Stator
Stator support ring
Rotor-bearing struts
Cylindrical seat
Thrust tie rod
Cylindrical seat
Stator torque truss
Radial spherical-ended columns
Support bridge for thrust bearings

Thrust and support system shows how independent mounting will be achieved



COMPO
OIL-RETAINING POROUS BRONZE BEARINGS
STOCK LIST NO. 4

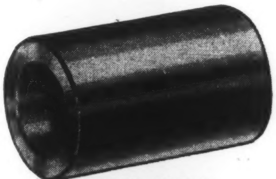
BOUND BROOK OIL-LESS BEARING COMPANY, BOUND BROOK, NEW JERSEY

NEW COMPO

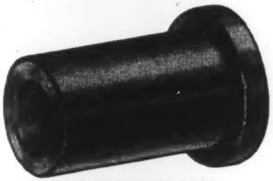
OIL-RETAINING POROUS BRONZE

BEARING

STOCK LIST NOW AVAILABLE

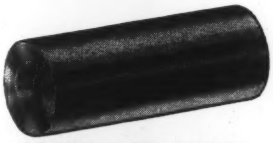


SLEEVE TYPE



FLANGE TYPE

BAR STOCK



CORED BAR STOCK

WASHERS

If you play a part in the design, production or maintenance of equipment using sintered bronze bearings, or if the job of purchasing bearings falls within your domain, you'll find a wealth of useful information within the 20 pages of the new Compo Oil-Retaining Porous Bronze Bearing Stock List No. 4. Bound Brook has compiled an easy-to-read list of the most popular stock sizes of bearings which are available for immediate shipment. In addition the Compo Stock List Brings you up-to-the-minute data on bearing application, installation, lubrication and machining. And here's another thought! When requesting your copy of the Compo Stock List why not have us send one to your supplier of bearing-using components or equipment? It may enable him to make savings beneficial to you both.

Write for a list of location of local warehouse stocks.

BOUND BROOK

BOUND BROOK OIL-LESS BEARING CO., EST. 1883, BOUND BROOK, N. J.

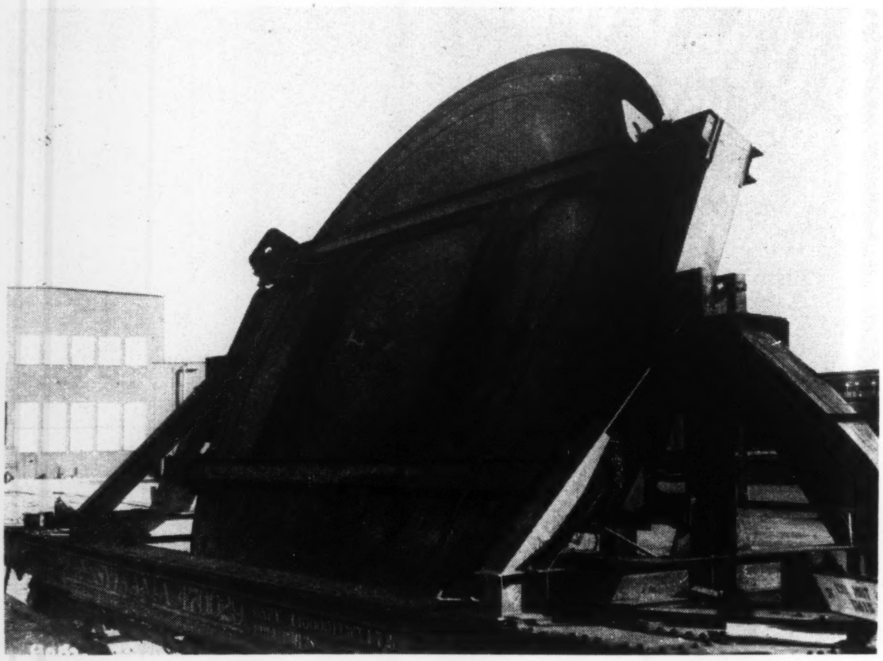
Pioneer in

POWDER METALLURGY BEARINGS + PARTS

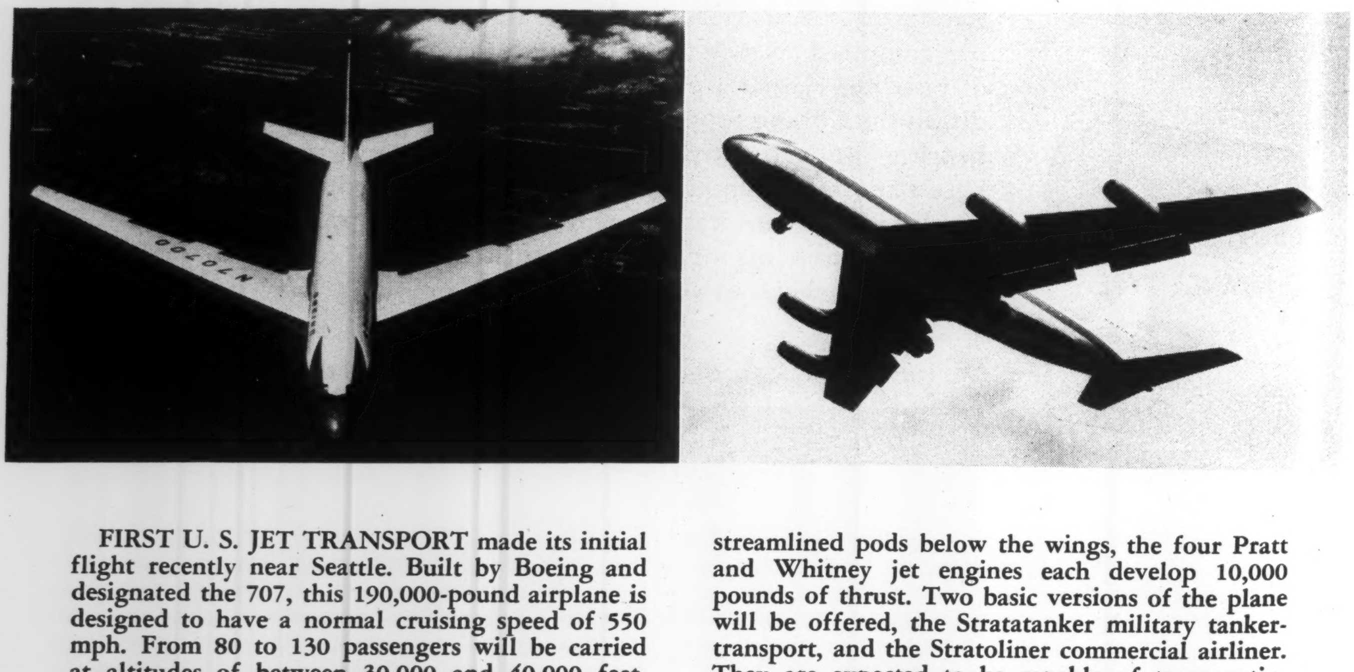
disturbing rotor alignment, the rotors will be supported independently of the bypass shell and tunnel structure. Weighing 11 million pounds, this freely supported supersonic compressor system will be maintained in accurate axial alignment, yet rigid enough to maintain high critical speeds.

Temperatures as high as 700 F are expected in the last compressor. Thermal expansion of the tunnel is restricted to the axial direction by guiding the supporting columns. These columns operate as large single ball bearings, allowing free movement of the stator during thermal expansion. Axial movement of as much as 5 inches is expected.

Lubrication problems caused by high temperatures and the problem of stopping the compressors after a test also highlighted the engineering development. Of particular interest to designers is the application of the detuning technique. To prevent dangerous resonant frequencies, rotor blades were designed to set their natural frequencies above lower multiples of the compressor operating speed. Westinghous reports this technique has never been used before in a project of this magnitude.



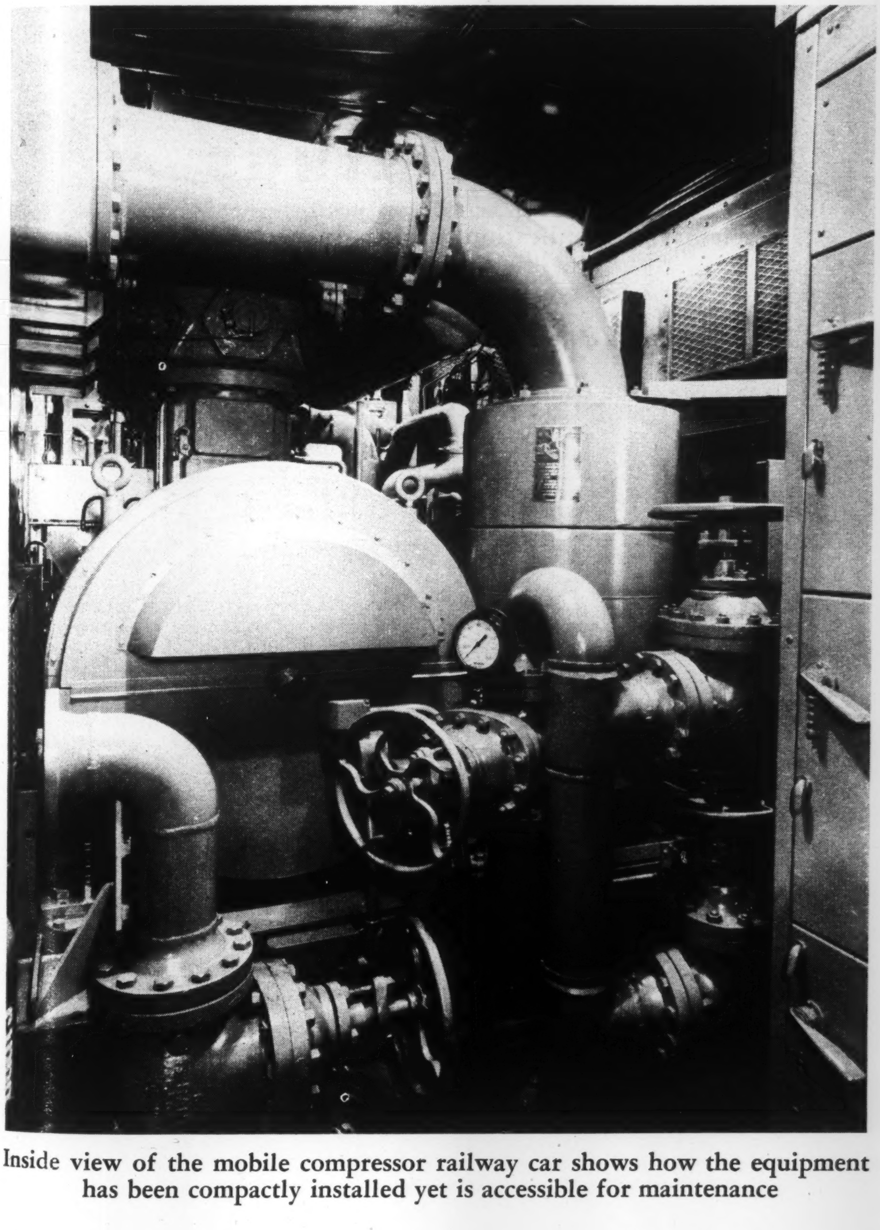
Shipping of the 18-foot diameter rotor disk from the forging plant in the east to the Westinghouse assembly plant in Sunnyvale, Calif. was accomplished by tilting it on a railroad flatcar



FIRST U. S. JET TRANSPORT made its initial flight recently near Seattle. Built by Boeing and designated the 707, this 190,000-pound airplane is designed to have a normal cruising speed of 550 mph. From 80 to 130 passengers will be carried at altitudes of between 30,000 and 40,000 feet. Four-segment landing flaps can be seen in the down position in the view at the left. Mounted in streamlined pods below the wings, the four Pratt and Whitney jet engines each develop 10,000 pounds of thrust. Two basic versions of the plane will be offered, the Stratatanker military tanker-transport, and the Stratoliner commercial airliner. They are expected to be capable of transcontinental nonstop flights in less than 5 hours and New York to London service of less than 7 hours

New Mobile Air Compressor Gets Quick Emergency Test

Said to be the first ever mounted in railroad cars, the first of a series of portable heavy-duty air compressors designed for the Navy was pressed into service on the day of its completion. Built by Clarke Bros. Co., the large mobile plant was rushed to a Naval shipyard to supply air while stationary compressors were being repaired.

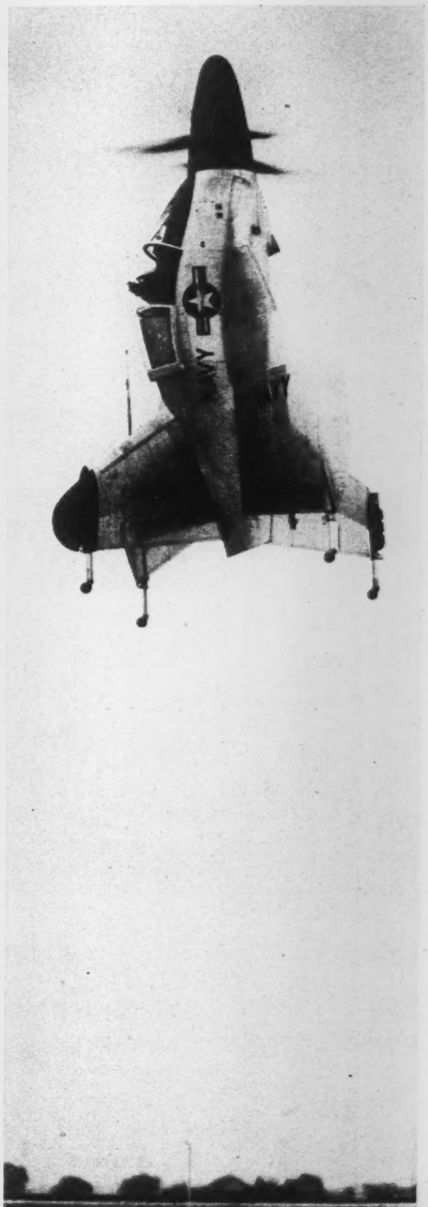


Inside view of the mobile compressor railway car shows how the equipment has been compactly installed yet is accessible for maintenance

Equipped with a pair of heavy duty compressors, the unit is capable of supplying a volume of 5000 cfm at a pressure of 125 psi. Said to be the first time units of this size have been made portable, the equipment weighs a total of 138,000 pounds including 500-horsepower electric motors, switchboard, transformers and cooling and lubricating systems. All this fitted into a standard 60-foot railway box car.

Although labeled emergency units, the compressors are designed for continuous service. During its recent emergency operation, this first plant is reported to have worked a regular 8-hour shift daily for 42 days.

(*Continued on Page* 24)



IT FLIES: First free flight of Convair's vertical-rising airplane took place recently. This turbopowered aircraft (MACHINE DESIGN, May, 1954, page 194) was previously flown with a specially designed tethering rig. During this latest series of free flights, a maximum altitude of 150 feet was reached. Although the plane has been designed to fly conventionally after taking off, horizontal flight will not be attempted until after preliminary vertical tests have been completed

The Amerigear® patented fully crowned tooth form...

...IS THE SOURCE OF

High Misalignment Capacit

Illustrating Full Cycle Misalignment Pattern of Amerigear H.M.C. *Patented Tooth Form.

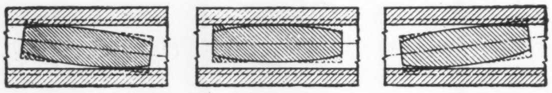
IN Amerigear®

COUPLINGS

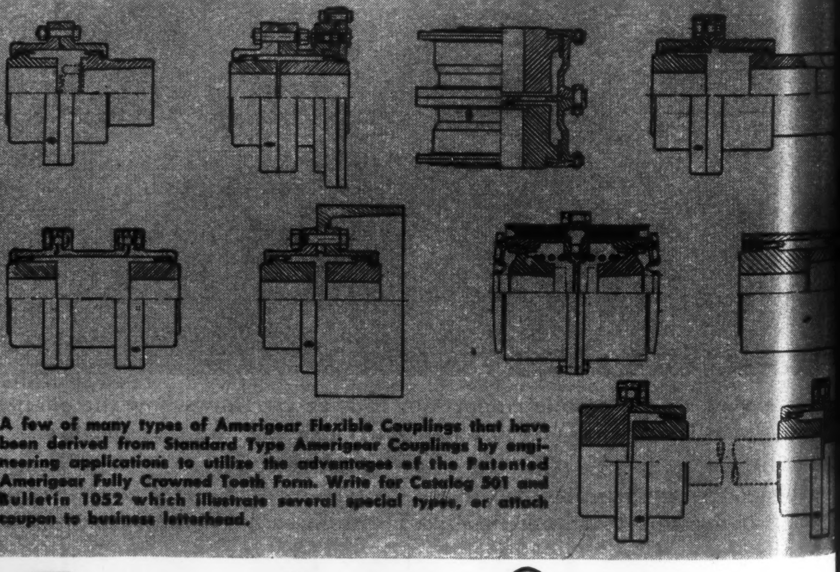
- An engineered application, using advantages of the Patented Amerigear HMC* Flexible Coupling, can solve any power transmission problem arising from:

- **Excessive lateral and angular misalignments;**
- **Tight backlash requirements;**
- **Space limitations;**
- **High speeds and loads;**
- **Continuous operation;**

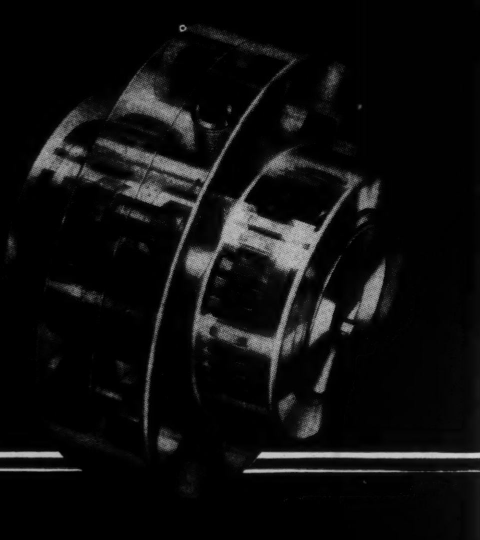
or any combination of these



Comparison with gearing of conventional gear-type couplings shows how Patented Amerigear Tooth Form eliminates *tooth end loading* and simultaneously allows for both lateral and angular misalignment. Dotted lines indicate gear teeth of conventional gear couplings.



A few of many types of Amerigear Flexible Couplings that have been derived from Standard Type Amerigear Couplings by engineering applications to utilize the advantages of the Patented Amerigear Fully Crowned Tooth Form. Write for Catalog 501 and Bulletin 1052 which illustrate several special types, or attach coupon to business letterhead.



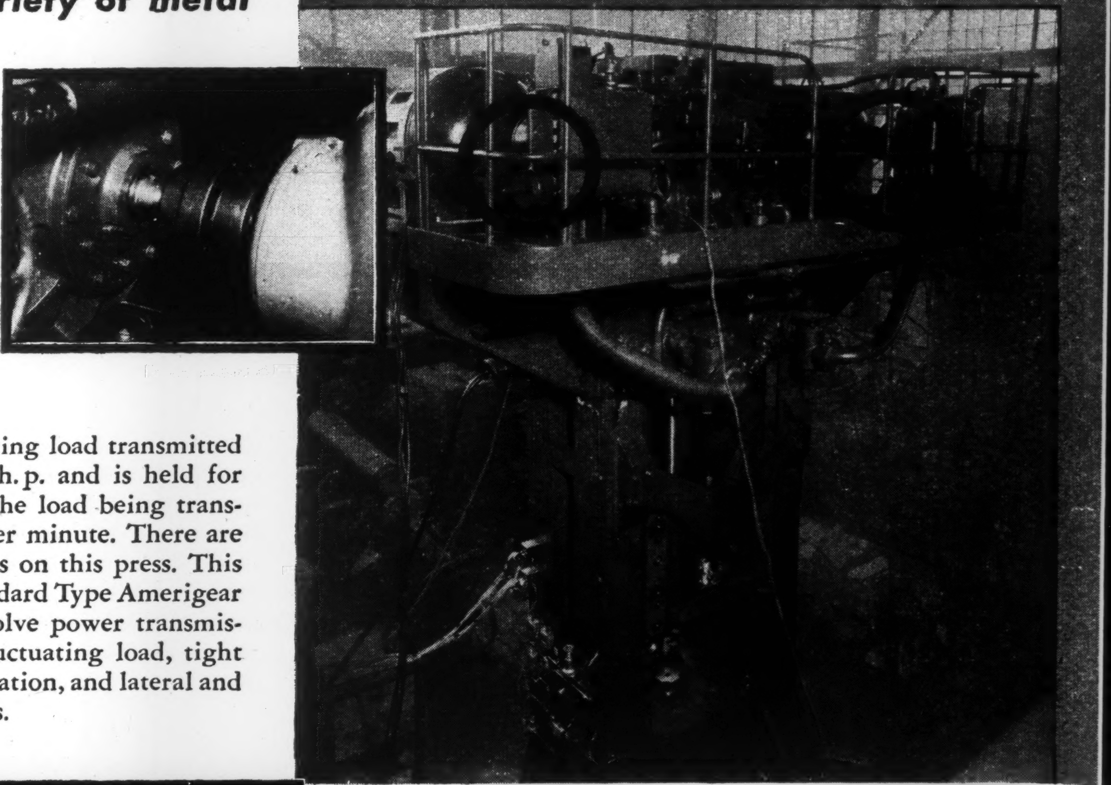
Amerigear® HMC* FLEXIBLE COUPL

One of several standard types embodying the P
Amerigear Tooth Form

Patented and Patents Pending

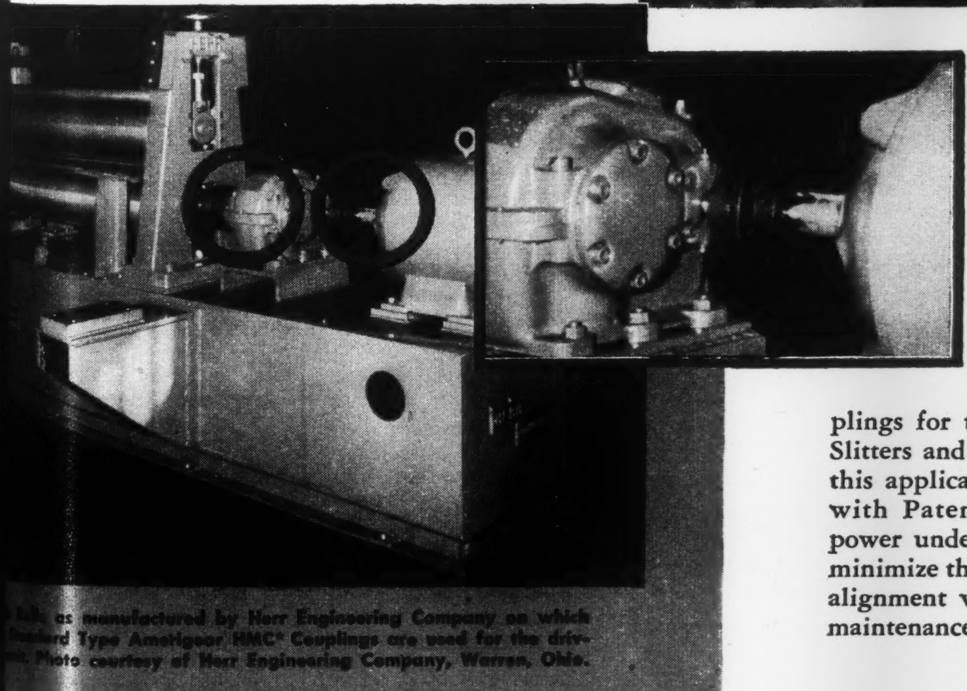
merigear® HIGH MISALIGNMENT CAPACITY* COUPLINGS

lve power transmission oblems for wide variety of metal rking equipment!



Bliss 350-Ton Capacity Hydro-Dynamic Press having dual pump and motor drive units which are equipped with Amerigear HMC* Couplings. Photo courtesy of E. W. Bliss Company, Canton, Ohio.

his application a Standard e of Amerigear HMC* pling is a vital part of the np and motor drive units a 350-ton capacity Bliss dro-Dynamic Hot Nosing ss. The pump and motor ve unit operating at 1200 .m. provides hydraulic ssure to operate the press n. Every 10 seconds the operating load transmitted reases from 125 h.p. to 150 h.p. and is held for proximately 2 seconds—thus, the load being transtted fluctuates several times per minute. There are pump and motor drive units on this press. This typical example of how a Standard Type Amerigear MC* Coupling is utilized to solve power transmisn problems arising from a fluctuating load, tight cklash requirement, space limitation, and lateral and gular misalignment conditions.



Rolls as manufactured by Herr Engineering Company on which Standard Type Amerigear HMC* Couplings are used for the drivnit. Photo courtesy of Herr Engineering Company, Warren, Ohio.

One of several applications of Standard Type Amerigear HMC* Couplings installed on Pinch Rolls manufactured by Herr Engineering Company. In this application two Amerigear HMC* Couplings are used; one on the rotating shaft between the motor and the gear reducer, and another between the gear reducer and the roll end. Herr Engineering also use Standard Types of Amerigear HMC* Couplings for their Pay-off Reels, Take-up Reels, Slitters and other steel finishing equipment. In this application Amerigear HMC* Couplings with Patented Tooth Form are transmitting power under shock loading conditions. They minimize the effect of any lateral or angular misalignment which may occur, thereby reducing maintenance costs to an all-time low.

Copyright 1954

erigear Engineers are available to assist in *engineering special applications* of the erigear Patented Crowned Tooth Form and for adapting Amerigear Standard e HMC* Couplings to solve your power transmission problems. Write for alog 501 and Bulletin 1052, or attach coupon to your business letterhead.

MERICAN FLEXIBLE COUPLING COMPANY

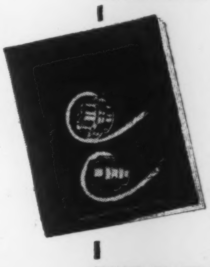
ZURN

Originator of the famous Amerigear Patented Tooth Form

Affiliate: J. A. Zurn Mfg. Co., Erie, Pa., U.S.A.

SALES OFFICES IN PRINCIPAL CITIES OF THE WORLD

In Canada: Canadian Zurn Engineering Ltd., 2052 St. Catherine St. W., Montreal 25, P.Q.



AMERICAN FLEXIBLE COUPLING CO. • Erie, Pa., U.S.A.

Please send me further information regarding AMERIGEAR COUPLINGS with the Patented Fully Crowned Tooth Form as described in Catalog No. 501 and Bulletin 1052.

Name .... *Title* ....

Company ....

Address ....

City .... *Zone* .... *State* ....

Please attach to your business letterhead.

Dept. MD 619

(*Continued from Page* 21)

Difficulty of design is indicated by specifications requiring standard parts to be used, accessibility for maintenance, compliance with AAR requirements for unrestricted box car travel, operation under wide ranges of temperature and high humidity conditions, and a restriction that the car and its equipment in operation vibrate no more than 0.030-inch in any direction.

Rearrangement of cylinders of standard compressors enabled the use of standard parts in the small space. Compact 500-horsepower synchronous motors driving each of the compressors are mounted in the end of the crankshaft with a motor bearing built into the compressor to conserve space. Need for a flywheel is eliminated by using a properly designed rotor.

Cooling air is drawn in by centrifugal blowers. Each compressor has its own cooling and lubricating system. Electrical input circuits permit operation with power supply of either 4160 or 2400 volts. Built in screw type jacks lift the car off the springs and with the ends of the car

Second Conference on Mechanisms

Memorial Union Bldg. on the campus of Purdue University at West Lafayette, Indiana, will be the site of the Second Conference on Mechanisms to be held on October 11-12, 1954. Again this year, the purpose of the Conference is to better acquaint designers and other engineering personnel with the capabilities and applications of mechanisms in automatic machinery as well as design of mechanisms for such applications. Joint sponsors of the Conference are the Mechanical Engineering Dept. of Purdue University and the Editors of MACHINE DESIGN and *Automation*.

Advance registration is advisable and may be made with the special postcard opposite Page 210 in this issue.

Fee for the conference is $15 per person which may be paid in advance or at the time of registration. All checks accompanying advanced registration should be made payable to Purdue University and mailed to Mechanisms Conference, Comptroller's Office, Conferences, Purdue University, West Lafayette, Indiana. Included in the registration fee are one ticket to the banquet on Monday October 11 and a copy of the Transactions.

Overnight accommodations are not included in the fee or registration and should be reserved in advance. Lodging is available in the Union Club in the Memorial Union Building on the campus at $3.50 single, $4.50 double and $6.00 twin. Accommodations are also available at the Fowler Hotel in Lafayette from $3.50. For those driving, reservations may be made at the Morris-Bryant Motel, or Cedar Crest Motel (2-3 miles north on U. S. 52); rates from $4.50 single. Also Green Acres Motor Court, 4 miles north on U. S. 52 has recommended accommodations.

Program—Second Conference on Mechanisms

Session I—Special Gearing
(10 a.m.—October 11)

Welcome
Prof. H. Solberg, *Purdue University.*
Beveloid Gearing
Albert S. Beam, *Vinco Corp.*

Session II—Mechanism Performance Analysis
(1:30 p.m.—October 11)

Calculating Dynamic Characteristics of Mechanisms
Prof. B. E. Quinn, *Purdue University.*
Predicting Performance of High-Speed Mechanisms
A. G. Nothmann, *Armour Research Foundation.*
Analysis of Mechanisms with High-Speed Photography
Evan A. Edwards, *Eastman Kodak Co.*

Conference Banquet
(6:30 p.m.—October 11)

Toastmaster: Colin Carmichael, MACHINE DESIGN.

Panel Group Discussions
(8:30 p.m.—October 11)

What is Mechanism Synthesis?
Chairman, Prof. A. S. Hall, *Purdue University.*
Mechanism Manufacturing Tolerances—How Good?
Chairman, P. J. Eisele, *Warner & Swasey Co.*

Session III—Cam Design Problems
(9:00 a.m.—October 12)

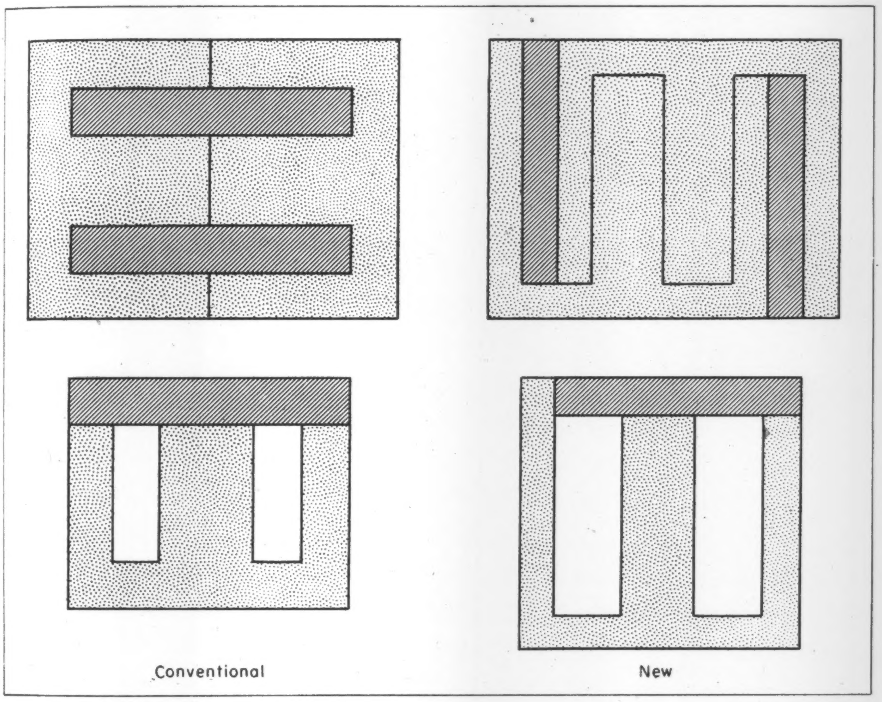
Cam Design and Manufacture
Paul Maker, *Bryant Chucking Grinder Co.*
Vibration Analysis of Cams
C. N. Neklutin, *Universal Match Co.*

Session IV—Control Mechanisms
(1:30 p.m.—October 12)

Straight-Line Mechanisms
W. R. Kearney and M. G. Wright, *Delco Radio Div.*
Proportional Control Mechanism
G. H. Giczewski, *Bowser, Inc.*

clamped to the rails, a firm foundation is provided during operation.

Besides being available for emergency uses, the compressor will effect economies at installations requiring only a temporary air supply. Construction projects requiring large air supplies may be served without the necessity of building a compressor building and concrete foundations.



BEFORE AND AFTER: New design for scrapless transformer laminations is expected to result in lighter weight transformers. Developed by Armour Research Foundation of Illinois Institute of Technology, these new laminations also give more window space, a feature expected to be useful in high-voltage applications. Lower no-load current is said to be realized because of the better joints that can be obtained. Although not expected to replace conventional scrapless laminations, the new design will be used to supplement them in certain applications

New Transistors May Shrink Brains

Brains, electronic that is, will be able to take better advantage of the ultraminiature size of transistors. Silicon, now replacing germanium in transistor construction, is said to afford higher power output and to double operating temperatures. Thus, more vacuum tube functions are expected to be taken over by these semiconductors.

First commercial production of silicon transistors is underway by Texas Instruments Inc. Production techniques developed by TI have permitted assembly line reproducibility of these new units.

Electronic computers now requiring great amounts of electrical power and large cooling systems are expected to be reduced to manageable size. Silicon transistors are said to have increased reliability and require much less power. In fact, 100,000 transistors use no more electrical power than an ordinary vacuum tube.

(*Continued on Page* 30)

What do you know about the
Moly-sulfide
A LITTLE DOES A LOT
LUBRICANT?

You may have heard about a highly successful solid-film lubricant which is giving remarkable results in the shop and in the field.

In one 40-page booklet we have collected 154 detailed case-histories describing how difficult lubrication problems have been overcome by molybdenum sulfide. If you wish to be up to date about this solid-film lubricant, fill in the coupon below, attach it to your letterhead and send it off today.

THE LUBRICANT OF MANY USES
Moly-sulfide
A LITTLE DOES A LOT

Climax Molybdenum Company
500 Fifth Avenue
New York City • 36 • N • Y •

Moly-sulfide

SEND FOR THIS FREE
BOOKLET TODAY

MOLY

Name..............................
Position..............................
Company..............................
Address..............................
MD-9 MS-3

ESNA's new lightweight product lines

Design specifications on these complete lightweight lines now available

All of these new self-locking nut product lines have been approved for use on Air Force, Army and Navy aircraft. Look them over—decide how much these weight reductions can mean to you.

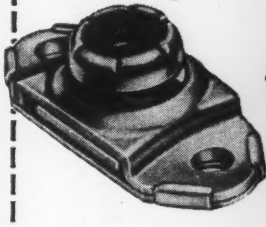
NEW!
ESNA BLUE "J's"

High strength aluminum-alloy nylon insert nuts. Weight saving — up to .82 lbs/100 pieces. Average 60%* lighter!

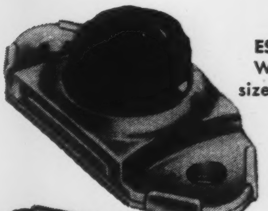
Save 115 lbs. per bomber— On a bomber the size of a B-52 ESNA Blue "J's" applied to steel bolts and used in place of AN steel self-locking nuts would eliminate 115 lbs. of fastener weight without sacrificing strength! Lubricated to minimize thread wear and galling. Hex nuts are offered with fiber or nylon locking inserts while anchor and channel types of "fixed" nuts are provided exclusively with nylon to permit extended reusability. *Completely interchangeable* with similar steel parts. Available in #6 through ¼" sizes . . . in every important hex and "fixed" nut configuration including floating basket nuts and straight and curved gang channel.

ESNA Type Y
Weight saving—¼—28
size=.36 lb/100 pieces.
40%* lighter!

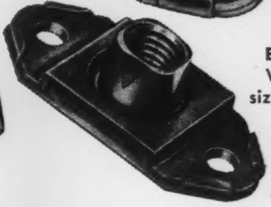
For ¼" sizes and above—Here is the new ESNA "12-point" nut, a steel part that meets AN365 tensile requirements with significant weight savings in sizes of ¼" and above. Double hex shape permits design improvements and easier installation for locations where wrenching clearance is limited.



ESNA Type NA401
Weight saving—
10/32 size=.51 lb/
100 pieces.
51%* lighter!

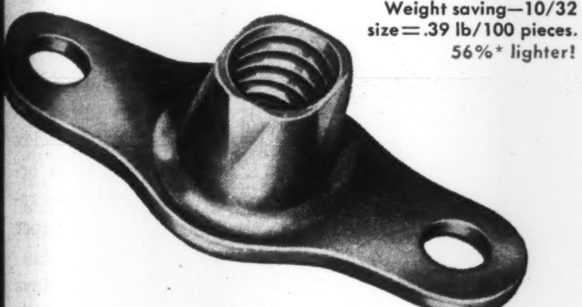


ESNA Type NAJ401
Weight saving—10/32
size=.64 lb/100 pieces.
64%* lighter!



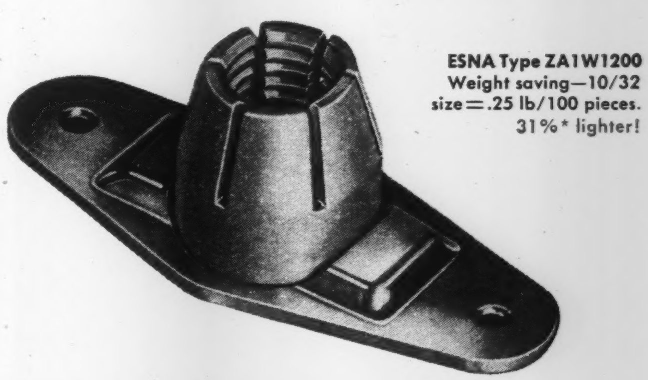
ESNA Type 12LHA401
Weight saving—10/32
size=.41 lb/100 pieces.
41%* lighter!

"Floaters"—When production methods result in the minor subassembly misalignments that make floating type nuts desirable, look to ESNA for lighter, stronger parts. Pictured are ESNA's newly designed steel floater and floaters from the aluminum Blue "J" and high temperature LH lines. Conforming to AN366 dimensions, better performance and lower weight have been accomplished without sacrificing tensile strength.



ESNA Type LHA1
Weight saving—10/32
size=.39 lb/100 pieces.
56%* lighter!

For temperatures to 550° F—ESNA's new LH lines are lighter high-temperature anchor nuts with a completely new locking device offering performance that meets Spec AN-N-10 and providing extended reusability. Approval has been issued for sizes #6, 8, 10 and ¼". Also available in one lug, corner, two lug floating basket and gang channel types.



ESNA Type ZA1W1200
Weight saving—10/32
size=.25 lb/100 pieces.
31%* lighter!

Easier welding of fixed fasteners—Here is a lighter stainless steel anchor nut to be used for temperatures up to 1200° F. Available with rivet holes or welding nibs. Unplated base plate of Type 321 stainless makes it particularly suitable for attachment by welding. A second nut, designed for temperatures up to 800° F. to meet AN362C requisites, is also available.

With these new parts, you can save weight on virtually all aircraft self-locking nut applications. Mail our coupon for design specifications.

ESNA®
TRADE MARK

Elastic Stop Nut Corporation of America

*These are typical weight savings compared with earlier ESNA designs for the same applications.

Dept. N63-94, Elastic Stop Nut Corporation of America
2330 Vauxhall Road, Union, N. J.

Please send me the following free fastening information:

☐ Product literature, samples of the following types:__________
☐ Please have an ESNA application engineer get in touch with me.

Name__________ Title__________
Firm__________
Street__________
City__________ Zone____ State__________

ANSWERS TO YOUR PUMP PROBLEMS

TUTHILL MODEL L SERIES
SMALL INDUSTRIAL PUMPS

CATALOG 101—(Model L Series) Mechanically-sealed pumps in capacities from ⅓ to 6 g.p.m. and pressures to 600 p.s.i.

These New TUTHILL Catalogs Give You Complete Data on Pumps for LUBRICATION, HYDRAULIC, COOLANT, TRANSFER and BURNING OILS SERVICE.

TUTHILL MODEL C SERIES
GENERAL PURPOSE PUMPS

CATALOG 102—(Model C Series) General purpose pumps in capacities from 2 to 200 g.p.m. and pressures to 100 p.s.i.

TUTHILL MODEL CK SERIES
HIGH PRESSURE PUMPS

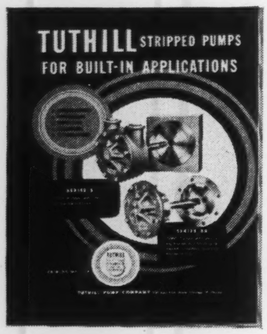
CATALOG 103—(Model CK Series) High pressure pumps in capacities from 5 to 200 g.p.m. and pressures to 400 p.s.i.

TUTHILL MODEL M SERIES
COOLANT PUMPS

CATALOG 104—(Model M Series) Coolant pumps with automatic internal by-pass. Capacities from 2 to 50 g.p.m. and pressures to 15 p.s.i.

TUTHILL MODEL R SERIES
AUTOMATIC REVERSING PUMPS

CATALOG 105—(Model R Series) Automatic reversing pumps in capacities from ¾ to 200 g.p.m. and pressures to 100 p.s.i.



CATALOG 106—(Types S and SA) Stripped pumps for built-in applications. Capacities from ⅓ to 200 g.p.m. and pressures to 100 p.s.i.

TUTHILL
TYPE SU

CATALOG 107—(Type SU) Multiple V-belt pumping units in capacities from 2 to 50 g.p.m. and pressures to 300 p.s.i.

Tuthill pumps are of the rotary, internal-gear, positive displacement type.
Any one or more of these Tuthill catalogs are available on request. They include individual pump guides to help you select the Tuthill pump best-suited to your requirements. Please ask for catalogs by number.

TUTHILL
PUMPS FOR THE PURPOSE

TUTHILL PUMP COMPANY
Dependable Rotary Pumps since 1927
939 East 95th Street, Chicago 19, Illinois

Canadian Affiliate—Ingersoll Machine & Tool Co., Ltd.
Ingersoll, Ontario, Canada

(*Continued from Page* 27)

Space and weight savings are expected to be considerable in aircraft and missile control equipment. Miniaturizing the electrical amplifying and controlling elements with the use of silicon transistors will also make possible the elimination of much associated equipment because of the reduced power demand.

New System Designates All Alloys

A new system of alloy designations for wrought aluminum and aluminum alloys goes into effect October 1, 1954. Developed by the Aluminum Association, the new series is expected eventually to replace all previous systems of identifying aluminum alloys.

Confusion brought about by many special designations used during World War II will be eliminated with the new four-digit index system. Users will be able to order by the same alloy number regardless of the supplier. Temper designations remain unchanged.

General grouping of the alloys under the new four-digit system is as follows:

Description	Index Number
Aluminum—99.00% minimum or greater	1XXX
Aluminum alloyed with:	
Copper	2XXX
Manganese	3XXX
Silicon	4XXX
Magnesium	5XXX
Magnesium and silicon	6XXX
Zinc	7XXX
Other element	8XXX
Unused series	9XXX

The first digit of each designation indicates the general group to which a given alloy belongs, by major alloying element. Minimum aluminum percentage is indicated by the last two digits. Any modifications in impurity limits are designated by the second digit. If the second digit is zero, it indicates no special control on individual impurities. A prefix X is used for experimental alloys.

To aid in the transition from designations previously used to the new system, many of the old numbers are retained as the last two digits of the new numbers. Thus, alloy 3S becomes 3003; 24S becomes 2024; and 61S becomes 6061. Additional designations, should they be needed, can be provided by the unused 9XXX series. Therefor, the system is said to be not only fully adequate to meet existing needs, but is sufficiently flexible to meet industry's future needs.

New Designations for Common Alloys

Old	New	Old	New
2S	1100	50S	5050
3S	3003	A51S	6151
4S	3004	52S	5052
11S	2011	53S	6053
17S	2017	56S	5056
18S	2018	61S	6061
24S	2024	62S	6062
25S	2025	63S	6063
32S	4032	75S	7075

• • • SONICS AND ELECTRONICS *are being used to measure and control the viscosity of fluid mixtures. First application of the system is to blending fuel oil. Viscosity of the blend is measured by a Bendix Aviation Ultraviscoson unit which utilizes a probe vibrating at ultrasonic frequencies. Amount of energy absorbed by the fluid from the probe is proportional to the viscosity. Information fed from the probe to a Minneapolis-Honeywell electronic control unit automatically opens and closes a valve to maintain correct viscosity.*

Power Steering Fits in Steering Column

A new power steering gear design incorporates all parts except the oil pump and reservoir into the steering gear housing. Size of the unit compares with that of a conventional steering gear. Developers of the gear, Chrysler Corp., have labelled it "Coaxial Power Steering."

In addition to reduced size and ease of installation comparing to that of a conventional steering gear, other advantages are claimed for the coaxial unit. Fewer parts are said to promise longer life without major adjustment and to reduce the probability of malfunction or failure. Lighter weight, in

(Continued on Page 36)

NEW
METALLIZED*
CERAMICS

FOR USE WITH BOTH HARD AND SOFT SOLDERS

Frenchtown's new *single metallic coating* on refractory ceramic bodies provides a surface to which solders with melting points from 275° F. to 1600° F. may be applied. No expensive, intermediate nickel and/or copper plating is needed to form a strong, firmly adhering bond with both hard and soft solders.

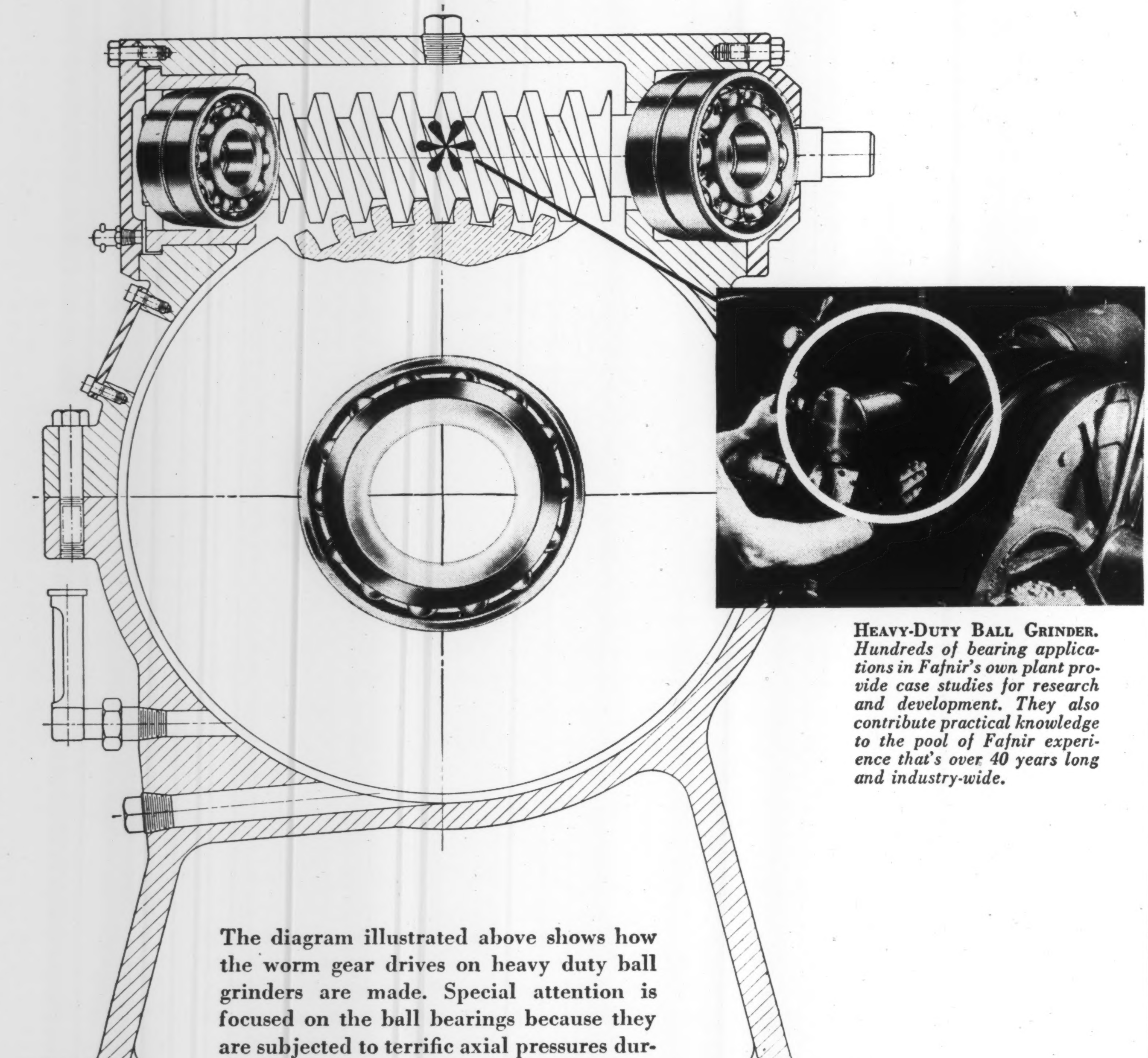
Now is the time to reexamine your requirements and specifications. Look to Frenchtown's new METALLIZED CERAMICS to save you production time and money. Phone or write for help on any problem involving the bonding of ceramics to metal parts or ceramics to ceramics.

*Patent Applied For

Frenchtown
PORCELAIN COMPANY
88 MUIRHEAD AVE. . . . TRENTON 9, N.J.

More Turns For The Worm

on Fafnir Ball Bearings



Heavy-Duty Ball Grinder. *Hundreds of bearing applications in Fafnir's own plant provide case studies for research and development. They also contribute practical knowledge to the pool of Fafnir experience that's over 40 years long and industry-wide.*

The diagram illustrated above shows how the worm gear drives on heavy duty ball grinders are made. Special attention is focused on the ball bearings because they are subjected to terrific axial pressures during grinding operations when balls pass between grinding plates and grinding wheels.

The effectiveness of this bearing application is a matter of record. On the worm gear shaft illustrated, the duplex pairs of bearings have been in operation for 16 years without replacement . . . protecting the worm gear by rigidly locating its shaft and affording adequate carrying capacity for the combined radial and heavy thrust loads.

If you have similar equipment, maybe we can help extend its service life. The Fafnir Bearing Company, New Britain, Conn.

FAFNIR

BALL BEARINGS

MOST COMPLETE LINE IN AMERICA

DON'T LET THE BIG ONES SCARE YOU!

(or the small ones either!)

- **We can supply Socket Head Cap Screws in any length you want up to 3″ in diameter . . . because we have blanks for these big babies Right in Stock!**
- **1¼″ and 1½″ diameters, individually packaged, are standard in all listed lengths — Right from Stock!**

HOLO-KROME
Completely Cold Forged
SOCKET SCREWS

Always quickly available
through HOLO-KROME
Authorized Industrial Distributors

THE HOLO-KROME SCREW CORP. • HARTFORD 10, CONN., U. S. A.

The Swing is to
Durakool
Factory Set
Timer Relays

FACTORY SET, TAMPER-PROOF TIMING

MERCURY RELAY
DURAKOOL INC.

Practically non-breakable, Durakool Factory Set Timer Relays have more than proved themselves on the roughest and toughest jobs that could be found. Year by year, their use increases in sensational fashion. Controlled time available from .15 to 20.0 seconds in either normally open or normally closed actions. No waiting. Your production schedule is met.

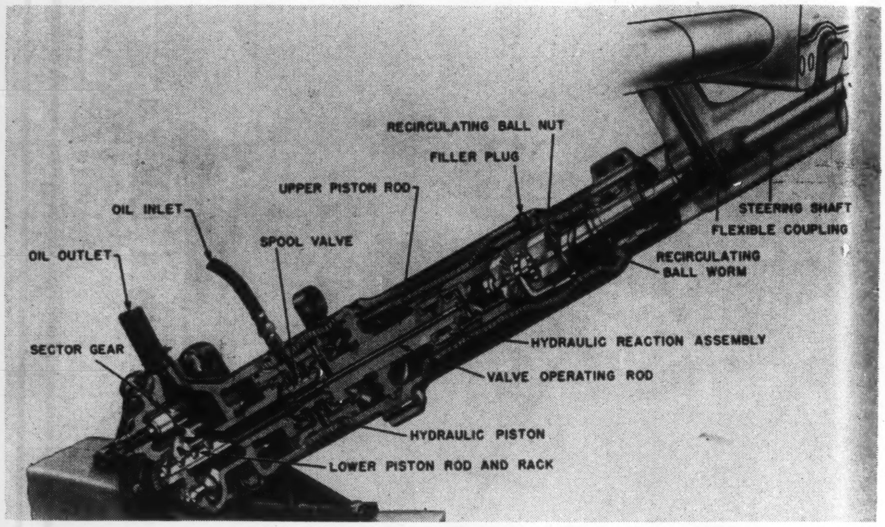
★ No false contacts
★ No chatter
★ Quiet in operation
★ Low in cost

See telephone directory for local distributor or write
DURAKOOL, INC., Elkhart, Ind.
50 St. Clair Ave., W. Toronto

Durakool
ALL-STEEL MERCURY
Timers

(*Continued from page* 31)

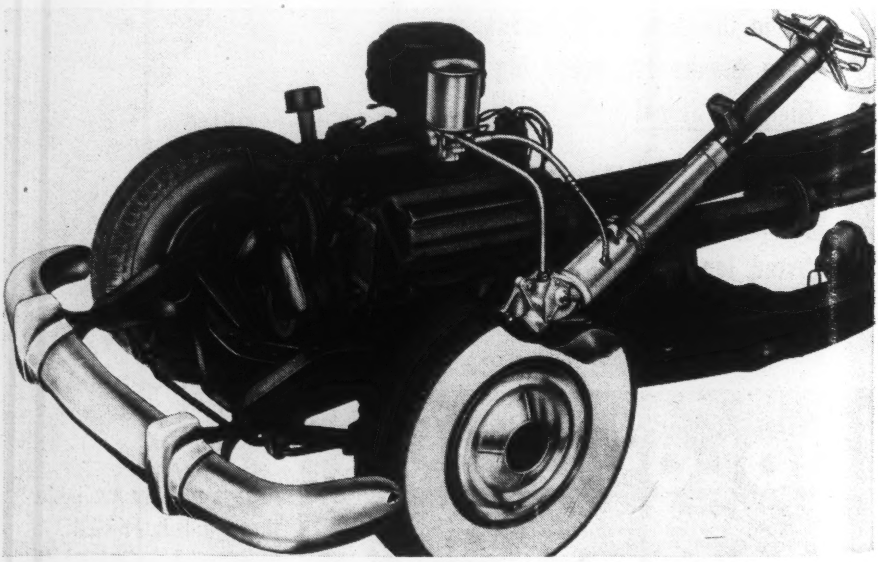
fact less weight than any other integral type production power steering gear, is claimed with no reduction in strength.


RECIRCULATING BALL NUT
FILLER PLUG
UPPER PISTON ROD
OIL INLET
SPOOL VALVE
OIL OUTLET
STEERING SHAFT
FLEXIBLE COUPLING
RECIRCULATING BALL WORM
SECTOR GEAR
HYDRAULIC REACTION ASSEMBLY
VALVE OPERATING ROD
HYDRAULIC PISTON
LOWER PISTON ROD AND RACK

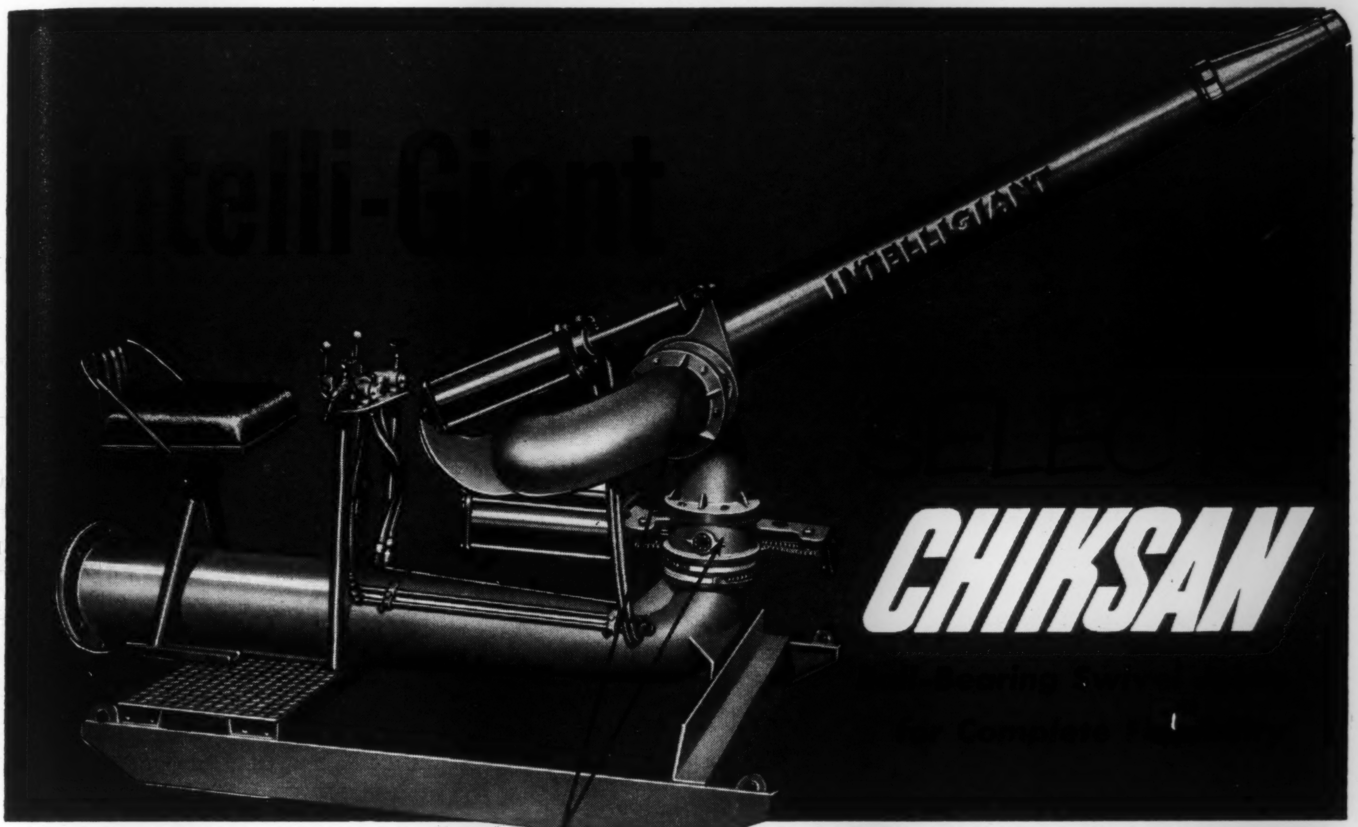
Conventional hourglass worm and roller have been replaced by recirculating ball nut, ball worm, and rack and sector in coaxial power steering gear. Hydraulic reaction assembly provides "feel" of the road at all times. Rack and sector are lubricated by hydraulic oil rather than heavier gear oil or extreme pressure lubricant

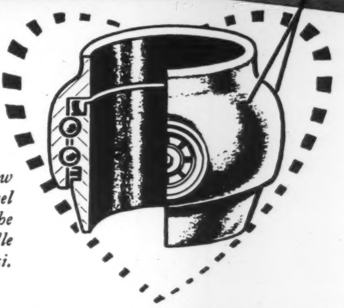
Design and construction of the steering gear are such that approximately 20 per cent of the steering effort required is provided by the driver of the car in which the gear is mounted while the power unit supplies the additional 80 per cent. No minimum effort is required by the driver before power assistance is supplied. Feel of the road is consistent because of the fixed ratio of driver effort to power assist.

Cars fitted with the coaxial gear have an overall steering ratio of 16.8 to 1 as compared to a ratio of 25.8 to 1 for those using conventional gears. Total turns of the



New power steering gear is a completely self-contained unit except for hydraulic pump and reservoir mounted on the rear of the generator. Housing is little larger than ordinary steering gear jacket tube





CHIKSAN style 20 low pressure 6" forged steel swivel joints, the "Heart" of the INTELLI-GIANT. will handle pressures up to 1,000 psi.

FIRST hydraulic GIANT improvement in 90 years

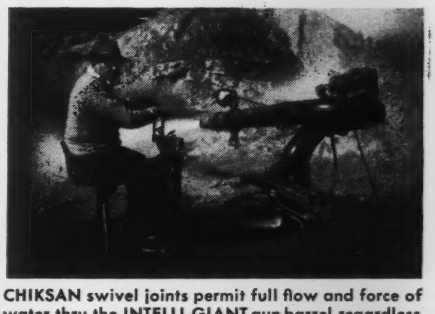
Made Possible with CHIKSAN

Increased efficiency and economy in extracting gold or moving dirt with water has been an objective of hydraulic mining engineers for the past 90 years. History and experience have proved that water power is unequalled by any mechanical devices thus far employed for such purposes.

But water under adequate pressures was hard to govern. And man's devices to control both flow and force in placer mining were both crude and inadequate.

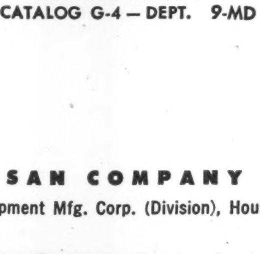
The early Hoskins Hydraulic Giants and their successor the Fisher Type machine, lacked the flexibility necessary to give complete control in traverse and vertical directions coupled with force and flow.

After 8 years of exhaustive engineering and field testing under the most exacting conditions, INTELLI-GIANT has selected CHIKSAN Ball-Bearing Swivel Joints as the solution to all the problems encountered in this unique field.



CHIKSAN swivel joints permit full flow and force of water thru the INTELLI-GIANT gun barrel regardless of angle. Controls are hydraulically operated.

CHIKSAN 6" low pressure swivel joints eliminate gasket replacements while handling adequate pressures from 30 to 300 psi. The INTELI-GIANT will traverse a 320° horizontal arc and cover 120° vertically.



WRITE FOR INDUSTRIAL CATALOG G-4 — DEPT. 9-MD

The Flow of Enterprise Relies on

CHIKSAN

Ball-Bearing Swivel Joints

CHIKSAN COMPANY • BREA, CALIFORNIA • Chicago 3, Illinois • Newark 2, New Jersey

Well Equipment Mfg. Corp. (Division), Houston 1, Texas • Subsidiaries: Chiksan Export Co., Brea, Calif.; Newark 2, N. J. • Chiksan of Canada Ltd., Edmonton, Alta.

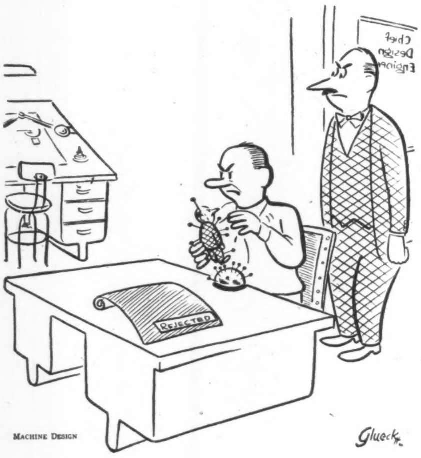
OFF SHELF DELIVERY!
New
COMPACT DESIGN SAVES UP TO 40% SPACE!
Proven
PERFORMANCE WITH EXTRA HIGH SAFETY FACTOR!
T-J
Spacemaker
CYLINDERS
OIL pressure to 750 — AIR to 200 P.S.I.
CIRCULAR HEADS WITH TIE RODS
SQUARE HEADS WITH TIE RODS
T-J
T-J
T-J
SPACE SAVED
T-J SPACEMAKER . . provides additional room for adjacent equipment without sacrificing strength.
T-J
TOMKINS-JOHNSON
RIVITORS . . . AIR AND HYDRAULIC CYLINDERS . . . CUTTERS . . . CLINCHORS

Now the sensational new T-J Spacemaker sets the pace in compact cylinder design and efficient performance!

New "Self-Aligning" adjustable oil cushion means faster acceleration and better cushion than ever before . . . New T-J Super Cushion Flexible Seals for air insure positive cushion with automatic valve action for fast return stroke.

More plus features include—heavy wall, precision honed, hard chrome plated, seamless steel body . . . leakproof cylinder head to body construction . . . heavy duty, high-tensile, ***hard chrome plated piston rod.*** Write for bulletin SM-454-2. The Tomkins-Johnson Co., Jackson, Mich.

steering wheel have been proportionally reduced from 5½ turns to 3½. In the event of a hydraulic power failure, the steering gear will still function as a mechanical unit to control direction of the car.


Chief Design Engineer
REJECTED
MACHINE DESIGN
Glueck

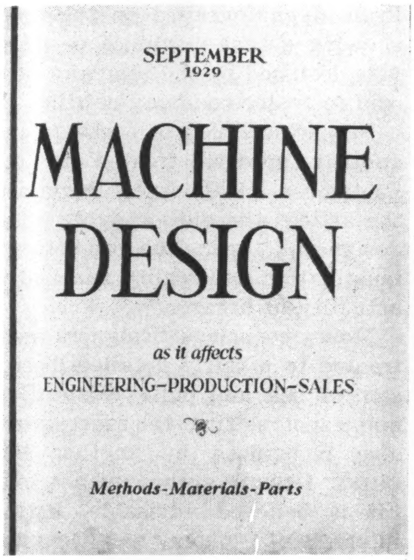
• • • HEAT AND HUMIDITY *affect electronic brains in about the same way as they do us humans according to Lt. Cmdr. Benjamin F. Emge Jr. of the U. S. Naval Development Center. To keep the huge "Typhoon" computer at the center from losing its ability to concentrate on the problem, a completely air-conditioned housing is used. As an additional precaution, weather-sensitive Minneapolis-Honeywell instruments check the brain's temperature and humidity and sound an alarm when it develops a temperature or becomes too humid.*

MACHINE DESIGN

Twenty-Five Years Ago

This month, on MACHINE DESIGN's twenty-fifth birthday, a look through the first issue emphasizes the rapid progress made in engineering and design. Some interesting contrasts can be found in comparing such things as modern jet-engine engineering, nuclear physics and electronic progress with engineering thinking of the 1929 era.

Twenty-five years ago this month, the first issue of MACHINE DESIGN offered its readers a choice of articles ranging from a discussion of welding in machine design to organizing a design department. Comprising a total of 66 pages, the magazine led off with an article entitled "Adjustments in Automatic Machines Test Skill of Designers." This dissertation involved the mechanics of an automatic bread-wrapping machine and its problems with out-of-tolerance loaves.



SEPTEMBER
1929

MACHINE
DESIGN

as it affects
ENGINEERING-PRODUCTION-SALES

Methods-Materials-Parts

"Where can welding be used in machine design and how much will it cost?" was the basis of an article in which the author announced that the public has accepted welding.

Electronics came into the picture in a two page story called "Photo Cell in Sorting Machine Excels Human Eye." The author wrote, "More and more is electricity becoming a vital factor in machine design."

Improved methods of gear cutting were outlined in another presentation showing interesting design possibilities using hypoid gearing.

A series titled "Organization and Supervision of Design Department" began in this first issue. Covering the choosing of personnel, the article emphasized good character and pleasing personality

Custom Engineered
MOLDED RUBBER PARTS

ACUSHNET specializes in "precision" molded rubber parts custom-engineered to specific requirements.

Utilizing the most modern techniques, our Engineering Staff constantly is developing new approaches to old problems, with notably successful results. By ingenious mold designing and skillful compounding, yesterday's skepticism of rubber for certain uses has changed to complete confidence in this versatile material as ideal for applications in countless vital assemblies.

Acushnet
PROCESS COMPANY

Consult our engineers on your next precision molded rubber job. In the meantime, send for a copy of the "Acushnet Rubber Handbook", a comprehensive rubber data reference for molded rubber parts.

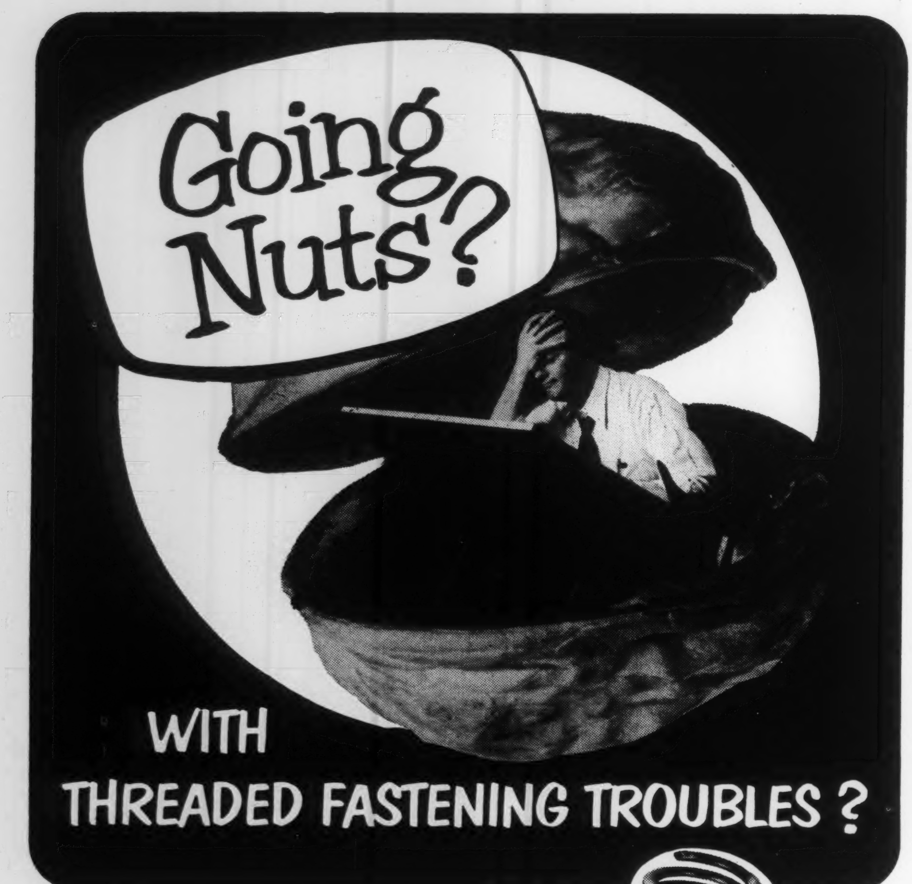
Address all communications to 762 Belleville Ave., New Bedford, Mass.

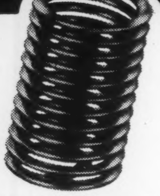
as a requisite of a good designer. Good furniture and good lighting to create confidence and permanence in the minds of the employees was also recognized. Framed photographs on the walls showing actual machines or products designed by the company were said to foster company spirit.

Proper selection of castings was another subject treated in the September, 1929 issue. Beginning the article, the author wrote, "The designer . . . spans the gap between imagination and reality and makes actuality of dreams."

Money-conscious designers were treated to a fairly detailed discussion of belt and pulley costs. Economics of setting tolerances were also recognized by another MACHINE DESIGN author who wrote, "It is believed advisable, in the interests of economy and accuracy, to consult the engineering, production, and inspection departments when setting tolerances." He

TURBINE DESIGN may be checked visually with this transparent nozzle. Used by General Motors Engineering Staff, the nozzle permits study of turbine blade shapes and angles for possible use in automobile torque converters and automatic transmissions. High speed photos can be taken under actual flow conditions


Going Nuts?
WITH
THREADED FASTENING TROUBLES ?



It *was* a problem making threads hold in softer, lighter materials...producing threads that would *never* wear, seize, corrode or gall.

But not since ***Heli-Coil**** Screw Thread Inserts! They make weak threads strong and *perfect*. And they save you weight, space and money because you can use fewer, smaller, shorter fastenings, smaller bosses and flanges.

When it comes to threaded fastenings, thousands of manufacturers throughout the world use ***Heli-Coil*** Screw Thread Inserts to answer their design, manufacture and field service problems. Send today for full information, specifications and samples. And a ***Heli-Coil*** Thread Engineer will be happy to assist at your request.

***Heli-Coil* Inserts conform to official Military Standards MS-122076 (ASG) through MS-124850 (ASG) and others.**

*Reg. U. S. Pat. Off.

HELI-COIL CORPORATION
129 SHELTER ROCK LANE, DANBURY, CONN.

☐ Please send samples and Bulletin 689—Military Standards Sheets.
☐ Please have a *Heli-Coil* Thread Engineer call.
☐ Send samples and Catalog

NAME________________________TITLE________________
COMPANY____
ADDRESS____
CITY____________________ZONE_______STATE__________ 2711

stressed co-operation in this matter.

Activities of the American Standards Association were featured prominently, indicating the increasing importance placed on industrial standardization.

Regular departments starting in this first issue included "Scanning the Field for Ideas." Featured was a machine in which electricity was used for something besides supplying motive power or generating heat. Electrical impulses were used to operate a stock-ticker type of device which, when properly interpreted, registered weight.

Another regular monthly department was entitled "Review of Noteworthy Patents." Described in detail was a newly patented machine adapted to operations "which heretofore involved disagreeable manual labor."

Extremely interesting was a feature called "How is Business?" Five charts illustrating various indexes of industrial activity indicated mostly new highs in late 1929. Text of this feature read in part, "In spite of record-breaking industrial activity, there are no signs of excessive inventories—a healthy condition."

Previews . . .

Quiet, Please!

If you've been bothered by stutters, crackles or blurred images on your TV set or radio, you can sometimes blame a designer who hasn't incorporated effective electrical noise suppression in his equipment. Electrical noise is easy to eliminate, as indicated in the article on Page 161, although detective work involved in finding the cause may require the skill of a Sherlock Holmes. But stringent Federal regulations, and often efficient functioning of the device itself, make it an important factor to consider.

Neither Heat nor Cold . . .

Silicones, like postmen, are particularly adapted to all kinds of weather. And silicones, like postmen, are often required to "carry the mail" in a wide range of ambient temperatures and conditions. Reason is, as T. A. Kauppi's article on Page 176 points out, that silicones have excep-

(*Continued on Page* 44)

BUILD YOUR
BUSINESS
ALONG THESE LINES

with **BIJUR**
Automatic Lubrication

By incorporating the Bijur System into your designs, you can offer substantial operating economies which progressive users now demand. For example, in the metalworking field 75% of machinery users prefer "built-in" automatic lubrication on the machines they buy.

Costly hand lubrication is eliminated.

Production time is saved because machines are oiled while in operation.

Bijur Automatic Lubrication is the best friend a bearing ever had. Every bearing is automatically fed a metered shot of oil at predetermined intervals.

Inaccessible bearings that require regular lubrication are never neglected.

There can be no problem of work spoilage or bearing headaches caused by over lubrication.

Leading machine builders have standardized on Bijur for a quarter of a century. Bijur puts the accent on engineering design — to satisfy the specific requirements of your machines.

Our engineers can show you how to build increased dependability into your machines, whether they are in production or still on the board.

0-4 *Write for literature and engineering data.* 2370

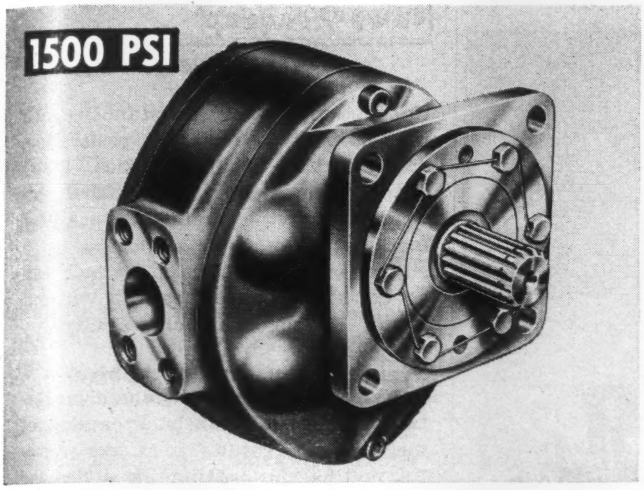
BIJUR
LUBRICATING CORPORATION
Rochelle Park, New Jersey
Pioneers in Automatic Lubrication

FOUR..

COMPLETELY NEW LINES OF HYDRAULIC PUMPS WHICH GIVE YOU FAR MORE IN PERFORMANCE AT FAR LESS IN COST!

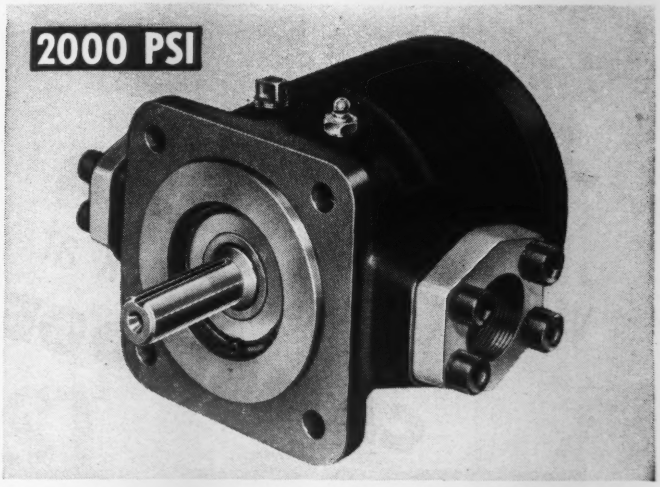
- Pumps to give new life to existing equipment . . . to improve performance, increase capacity!
- Pumps that afford the design engineer the basic equipment for entirely new concepts in hydraulically operated machines!
- Pumps for machines to do work better, quicker, cheaper!

THE NEW YORK AIR BRAKE COMPANY
1106 EAST 222nd STREET • CLEVELAND 17 • OHIO



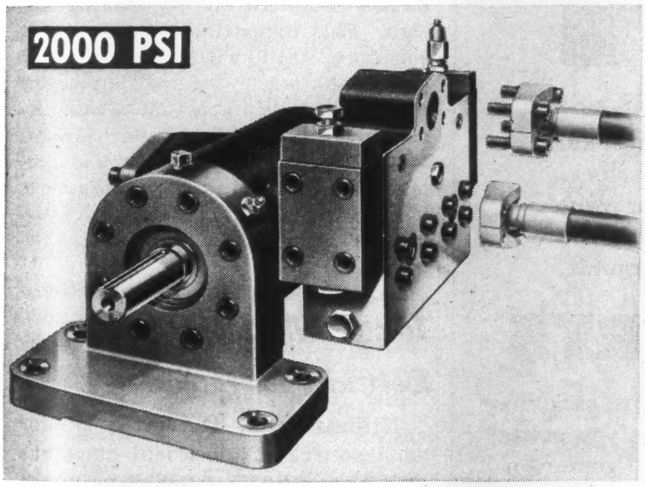
SERIES H GEAR-TYPE PUMPS

The HYDRECO Series H Pumps are intended for use in the hydraulic systems of heavy-duty mobile and industrial equipment, especially where shock loads, impact and rugged service are "normal working conditions". Four sizes (40, 50, 60, 70 gpm) deliver fluid power at 1500 psi . . . increased horsepower gives greater work output. *Pressure-Balanced* wear plates reduce oil slippage and eliminate power-robbing frictional contacts. SAE Flange Mounting and split-flange hose connections make servicing simple and reduce down-time, Equipment is on-the-job longer.



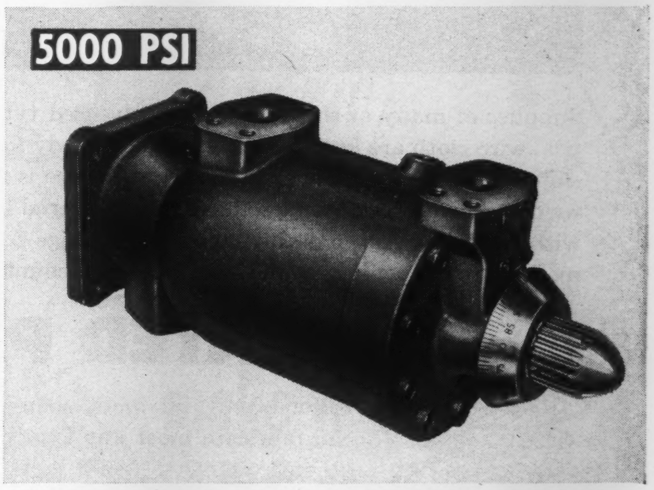
SERIES PF-100 VANE-TYPE PUMPS

DUDCO PF-100 Series Pumps can double the value of your *hydraulic dollar.* You get 2000 psi continuous duty, single-stage construction for the cost of equal capacity low pressure pumps . . . improved equipment design and increased machine efficiency without the payment of premium prices. These Pumps feature a simplified, 3-unit construction . . . the pumping cartridge incorporates the famous DUAL-VANE design which provides and assures complete balance of all hydraulic pressure loads. These Pumps have capacities of 3, 5, 8 and 11 gpm at 1200 rpm.



SERIES PF-100 DOUBLE PUMPS WITH VALVE PANELS

DUDCO PF-100 Series Double Pumps with Valve Panels are versatile units unmatched as a source of *Controlled Fluid Power* for a wide variety of modern industrial equipment . . . for 2000 psi operation of circuits calling for a substantial variation in pump volume as during "close and hold" or "traverse and feed" cycles. The Valve Panel contains the valving necessary for pressure regulation and flow control . . . the external part of a system will have less valves and controls, reduced piping and fewer parts to maintain. Ten capacity combinations with either automatic or remotely controlled operation.



SERIES PV-600 PISTON-TYPE PUMPS

DUDCO PV-600 Series Variable Delivery Pumps generate continuous duty pressures up to 5000 psi. Two types of controls match pump output to system demands. A pressure-compensated regulator automatically varies the volume in response to system pressure. A hand wheel control enables an operator to vary the volume during the machine cycle. High pressure variable delivery means power is transmitted without the necessity for an accumulator and without any wastage of power thru a relief valve.

WRITE TODAY . . .

Get full particulars on these important new developments in hydraulic pumps!

The New York Air Brake Company
1106 East 222nd Street
Cleveland 17, Ohio

Please send details on

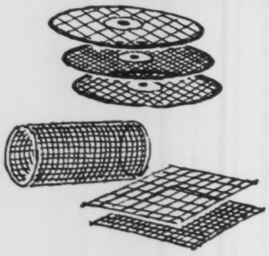
☐ SERIES PF-100 VANE-TYPE PUMPS
☐ SERIES H GEAR-TYPE PUMPS
☐ SERIES PF-100 DOUBLE PUMPS WITH VALVE PANELS
☐ SERIES PV-600 PISTON-TYPE PUMPS

Name________________________
Address________________________
City____________Zone______State________

your **WIRE CLOTH** needs may be in stock at **CAMBRIDGE**

Supplies of many of the most frequently used types of industrial wire cloth are kept in our warehouse ready for immediate shipment to you. And even if the type you use is not in stock, we can schedule our looms to have your material in your plant without delay. Any metal or alloy; sizes range from 20 x 250 mesh up to 4″ openings...and accurate mesh count is our pride.

also **FABRICATED PARTS**



Filter leaves, strainers, sizing screens, etc. We can fabricate most any type of part you need, in any quantity. We'll work from your own prints or, if none are available, our Engineering Department will draw up prints from your description of what the part must do. Once you've O.K.'d them, we'll start production.

Why not have us quote on your next order for wire cloth in bulk or fabricated parts? Write direct or call in your Cambridge field engineer. He's listed under "Wire Cloth" in your classified telephone directory.

Cambridge
WIRE CLOTH
METALLIC SCREEN
METAL PRODUCTS

FREE CATALOG gives full range of wire cloth available, also shows fabrication facilities and includes valuable metallurgical data. Write for your copy today.

The Cambridge Wire Cloth Co.

WIRE CLOTH | METAL CONVEYOR BELTS | SPECIAL METAL FABRICATIONS

Department N
Cambridge 9,
Maryland

OFFICES IN LEADING INDUSTRIAL AREAS

News Roundup

(*Continued from Page* 41)

tional temperature resistance (both high and low), moisture resistance, and electrical characteristics. They can also be made in an almost unlimited number of material types. For instance, the latest seems to be a silicone-rubber baby nipple which can be boiled to a fare-thee-well without losing its succulent chewability.

Stenography for Mechanisms

Mixture of a new "shorthand" notation, plus a Sears Roebuck catalog of mechanisms, results in a very useful method for setting up a desired motion, Page 167. In the method, motion requirements are set forth as a symbolic notation, and the catalog is used to find mechanisms that perform according to specifications. It's a very systematic approach to an often puzzling problem.

Shake Well Before Using

A prescription for consumer acceptance of a product will always include the best in engineering design. But industrial design, which concerns itself with acceptance of good engineering by the purchaser, may be equally important. Certainly, as industrial designer Peter Muller-Munk points out on Page 148, cooperation between the two professions is necessary. And, as Mr. M^2 says, the results are usually well worth the effort.

Tractor Will Supply Electricity for Farm Use

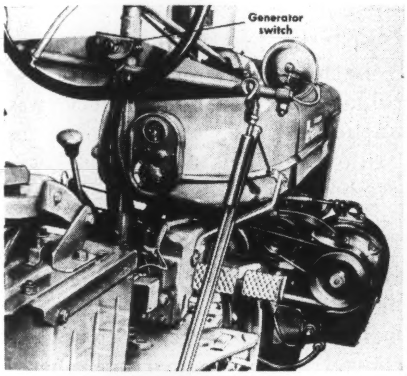
Utilization of the farm tractor as a source of electrical power as well as mechanical power will soon be realized. International Harvester engineers, working with engineers of General Electric, are developing a new tractor-mounted generator to bring electrical power to remote points on the farm where

Tractor-mounted generator is driven from the tractor engine through gears and a pulley to a V-belt drive work is to be done.

Under development for six years, the unit will supply 220-volt, 3-phase 60-cycle current for large motors, 220-volt single phase for loads such as electric ranges, and 110-volts single phase for small motors and power tools. Continuous output is expected to be about 10 kva.

Mounted on the engine, the unit is driven by a V-belt. Generator output is taken by a cable. If desired, the generator may be detached from the machine when not in use.

Design problems which had to be overcome in the development of the unit were physical size, electrical output, and versatility. Units had to be small, light and compact and had to conform to tractor-mounting and farm machinery requirements. Since they would be outdoors most of the time, they had to be designed to resist all types of weather conditions. Further, they had to be engineered for quick and easy mounting and demounting. Power connectors for example, were adapted from standard aircraft apparatus.



Installation of the new tractor-mounted generator showing the V-belt drive. Control of tractor-pulled farm machinery may be by means of a switch on the tractor panel

Advantage of the unit is expected to be in the operation of farm machines pulled by a tractor. Combines or automatic hay balers may be electrically operated, thus simplifying control from the tractor seat. Electric power will be available to operate portable saws,

Post lantern of rust-proof Zinaloy* by Phil R. Hinkley. Dull black finish.

Funnel of rust-proof M & H zinc used on fertilizer spreader. By Ontario Drill Co.

M & H zinc gripper on gelatin film eliminates ruinous rust. A Heyer Corp. product.

Rain carrying equipment of rust-proof Zinaloy* by Barnes Metal Products.

if RUST means RUIN...

make it of ZINALOY*

*Zinc alloyed with copper and magnesium to meet your temper needs.

THINK ZINC

Non-Corrosvie
Non-Magnetic
Self-Lubricating
Non-Staining
Non-Toxic
Non-Resonant
Easily Worked
Easily Finished
Wears Evenly
Non-Sparking

Rust means early ruin for thousands of products—*unnecessarily!* Why use material that rusts when Zinaloy* costs so little, adds so much to product value, sales appeal. Available in the temper you need, easily worked, durable, and positively rust-proof, Zinaloy* is easily finished, attractive unfinished. For a dramatic product improvement, for a new sales feature, use Zinaloy*.

M & H Zinc and Zinaloy is available in sheets and coils.

Write for a sample and literature on Zinaloy.

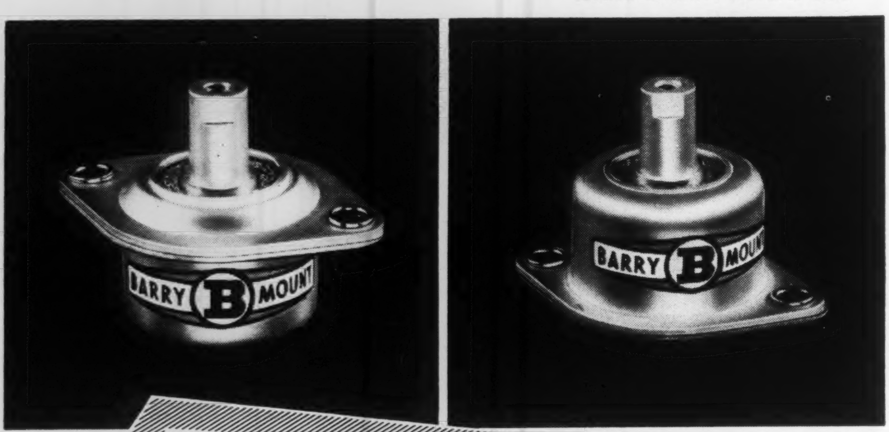
MATTHIESSEN & HEGELER ZINC COMPANY
General Offices & Works—LaSalle 12, Illinois
Eastern Sales Offices: 3415 Woolworth Bldg., New York

the **NEW** *miniature*

...**ALL-METL**

BARRY **B** MOUNT

UNITS SHOWN ACTUAL SIZE



for all-temperature vibration protection of airborne equipment

These new isolators are
the latest addition to the famous
Barry ALL-METL line.
They are specifically designed to help you meet miniaturization demands under toughest environmental conditions.

Temperature range — from −60°C to +175°C
Weight — only ½ ounce per unit isolator
Height — only 1¼" free, 25/32" bottomed
Load ratings — 0.1 to 3.0 lbs. per unit isolator
Performance — meet all relevant requirements of JAN-C-172A/MIL-C-172B
Ruggedized — to meet shock tests under specifications AN-E-19, MIL-E-5272, MIL-T-5422B, and MIL-C-172B.
Mounting styles — available in plate and cup types, as illustrated, for 2-hole or 4-hole mounting.

For complete information, ask for your free copy of the new Barry Product Bulletin 542, containing full installation and performance data. And for greatest benefits with these new isolators, let our Field Engineering Service help in the early stages of your equipment design.

THE **BARRY** CORP.

722 PLEASANT STREET
WATERTOWN 72, MASS.

SALES REPRESENTATIVES IN ALL PRINCIPAL CITIES

British Licensee: Cementation (Muffelite), Ltd., London, England

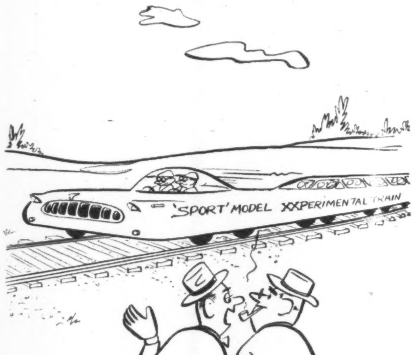
electric drills, welding equipment or temporary lighting installations.

• • • COLORED TV, *not color TV, has been made available by Motorola Inc. in the form of gaily colored plastic television set cabinets. Colors offered are Tan, Driftwood, Burgundy, Terra Cotta, Candy Yellow and Avocado green. Chicago Molded Products Corp. is making the cabinets of Plaskon urea which is said to be colorfast, easy to clean, non-electrostatic and a good insulator.*

Announces New Supertough Steel

Steel, having a minimum yield strength three times that of the ordinary mild-carbon variety, was announced recently. Known as Carilloy T-1, this new product was developed by U. S. Steel researchers.

Important point in its applications is said to be the possible elimination of stress relieving. During recent tests, both stress-relieved and nonstress-relieved welded pressure vessels failed at the same internal pressure. Elimination of this special heat treatment after fabrication is expected to make possible larger field-fabricated vessels. For example, a pro-



"It was bound to come—"

pane storage vessel made of T-1 may be built to a diameter of 65 feet and hold 65,000 barrels. Maximum diameter now permitted without stress relief is 22 feet with a capacity of 1000 barrels.

Carbon content of T-1 is 0.15 per cent. Some of the alloying elements used are manganese, nickel, chromium and molybdenum. Boron is added to increase hardenability and improve weldability.

Microstructure is tempered martensite. Its inherent toughness resists brittle behavior under adverse conditions, especially at low temperatures. T-1's use in power shovels points up its outstanding toughness in low temperature service.

While T-1 costs about 2½ times as much as ordinary mild-carbon steel, weight reduction results from the decreased thickness possible for the same working stresses. Consequently, freight and handling equipment costs are lower. Weight savings may also be realized in increased payload on barges, ships, truck tanks and railroad tank cars.

New Record Set In Aluminum Production

Record-breaking pace set by the U. S. aluminum industry during the first half of 1954 was climaxed with a quarterly production high of 732,515,499 pounds.

According to the Aluminum Association, primary production in the first half of 1954 was almost 20 per cent over that during the same period of 1953.

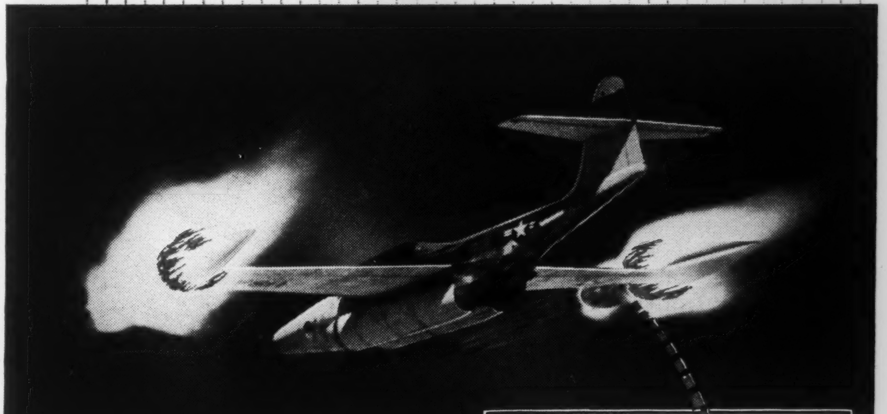
Increased expansion in the aluminum industry promises even greater increases in production. Capacity operation of new equipment is expected to set new records in 1955.

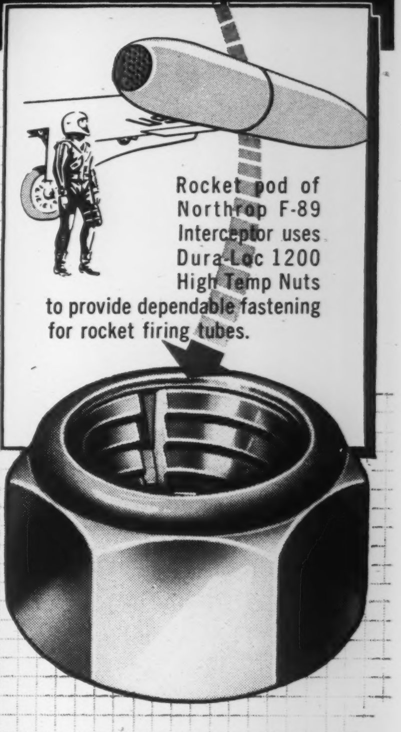
Considerably more metal is available now for civilian and military uses as a result of the greater production. New uses in both new and established fields are said to be developing daily.

National Metals Exposition will be held in Chicago, November 1 to 5, 1954. A near-record turn-

3rd of a Series

...another
JET-HOT FASTENING PROBLEM
solved by Delron





Rocket pod of Northrop F-89 Interceptor uses Dura-Loc 1200 High Temp Nuts to provide dependable fastening for rocket firing tubes.

problem: The Northrop F-89 all-weather interceptor carries large numbers of devastating rockets in wing tip pods. Northrop engineers required a self-locking nut for installation of rocket firing tubes operating under high heat and stress. Nuts were to stay locked under extreme vibration and high temperatures, yet present no problem on removal.

solution: Dura-Loc 1200 High Temp Nuts successfully met all requirements of this spectacular application, and are specified by Northrop on all F-89's now in production. The dependable service record throughout industry of many millions of nuts has proven the safety, reuseability and labor-saving features of Dura-Lock High Temp Nuts.

This is another example of Delron's long service and design experience at work—solving critical fastening problems!

WHAT IS YOUR CRITICAL FASTENING PROBLEM?

THE DELRON COMPANY, INC.
5224 Southern Avenue, South Gate, California

Clip this ad to your letterhead, and mail for product data on items checked: MD-3

☐ Fasteners to 1200°F. operation
☐ Fasteners to 1600°F. operation
☐ Sandwich structure fastening

Name__________

Pump manufacturer *standardizes* on LATTICE BRAID* Packing for *all* centrifugal pump models

*Registered Trademark. *Only* Garlock makes LATTICE BRAID rod and shaft packings.

Peerless Pump Division, Food Machinery and Chemical Corporation, Los Angeles, manufactures an entire line of centrifugal pumps. Before changing to LATTICE BRAID, Peerless regularly received frequent complaints on packing from their customers. Now that Peerless has *standardized* on LATTICE BRAID, complaints are rare. In addition, Peerless reports that LATTICE BRAID *resists* the excessive gland pressure often applied by uninformed repairmen. The result is that there is *less* packing and sleeve wear.

Put Garlock LATTICE BRAID Packing to work for your company. All the braided strands of this unique packing are lattice linked together into one structural unit. The strands hold together even when the packing is worn far beyond the limits of wear of ordinary braided packings.

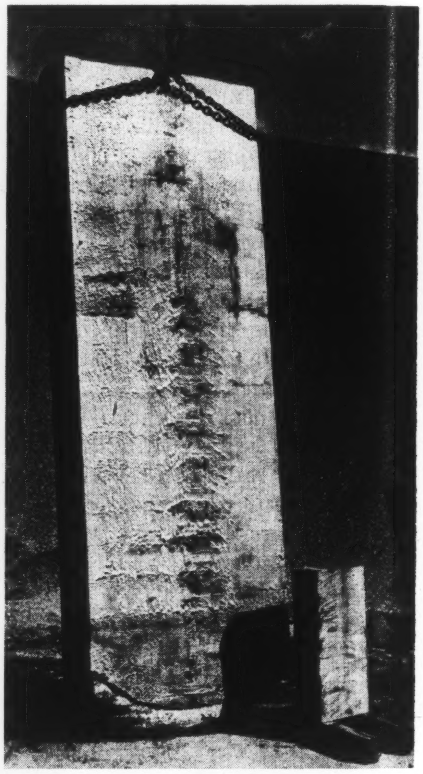
LATTICE BRAID is made from flax, cotton, asbestos, wire-inserted asbestos, Teflon, and asbestos with Teflon impregnation—for various types of services.

Get all the facts about LATTICE BRAID *Packings. Contact your Garlock representative or write for new folder AD-131.*

THE GARLOCK PACKING COMPANY, PALMYRA, NEW YORK
Sales Offices and Warehouses: Baltimore • Birmingham • Boston • Buffalo • Chicago • Cincinnati • Cleveland Denver • Detroit • Houston • Los Angeles • New Orleans • New York City • Palmyra (N. Y.) • Philadelphia Pittsburgh • Portland (Oregon) • Salt Lake City • San Francisco • St. Louis • Seattle • Spokane • Tulsa.
In Canada: The Garlock Packing Company of Canada Ltd., Toronto, Ont.

GARLOCK LATTICE BRAID PACKING

out of exhibitors is expected with new displays of existing products as well as brand-new products.



ONE-TON magnesium rolling ingot, left, was continuously cast at Dow Chemical Co.'s new Madison magnesium mill. This ingot, rolled on an 84-inch reversing hot mill, is shown compared with a 150 pound rolling ingot used prior to the installation of the new mill

AIEE Membership Hits All-Time High

Membership in the American Institute of Electrical Engineers, reported to be the largest technical society of its kind, has reached an all-time high of 48,515.

Starting with 71 members in 1884, the society has increased its membership each year except for the depression years of 1932-1936.

Five new sections were authorized by the Board of Directors, bringing the total to 105 in the

United States, Canada and Mexico. Eight subsections have been added, bringing the total to 60.

Survey Reveals More Salary Data

Minimum salaries that would be offered to graduate engineers was the subject of a recent survey conducted by North Carolina State College of Agriculture and Engineering. In its monthly paper, *Statelog,* the college reported results of a questionnaire asking the minimum salary each company would offer engineering graduates.

Trend in each field was:

	Number of Companies Reporting	Minimum Average Salary
Mechanical	98	$347.40
Aeronautical	21	352.19
Electrical	72	350.26
Ceramic	13	347.15
Chemical	53	353.26
Civil	39	342.31
Construction	16	325.18
Geological	1	350.00
Industrial	46	337.30
Heating and Air Cond.	16	352.50
Nuclear	11	359.73

Salaries offered by government agencies or TVA were not included in the survey. Government agencies are reported to be offering graduating engineers a minimum of $3410 a year while TVA is offering $3875 a year.

• • • POWER PILL *is the designation given a new thermostatic valve for use in pressurized industrial cooling systems as well as those of automotive vehicles. Charged with a wax compound rather than the usual volatile liquid or gas, the unit, made by Fulton-Sylphon Div., Robertshaw-Fulton Co., is said to be unaffected by pressure in a cooling system due to the use of the wax compound which melts and expands as it is heated.*

Sound Waves Test Titanium

Equipment used for the ultrasonic testing of steel has been adapted to test titanium. Republic

Leach CORPORATION

blueprints

FOR PROGRESS

one dependable source ... for specialized electrical equipment

An organization streamlined for maximum efficiency ... a combination of specialized and diversified talent, experience and facilities essential for the development and production of electrical components and assemblies which meet the fast-changing requirements of industry.

Leach comprehensive experience in research, engineering, manufacturing and service, on electrical, electronic and electromechanical equipment, have constantly been and are still being expanded for more efficient operation, stepping up production, thereby lowering costs to customers.

Put this specialized and technical experience to work on your specific requirements, to assure the full performance originally built into all products.

For aircraft, commercial and industrial efficiency and safety ... *Leach* has become *The Most Trusted Name in Specialized Electrical Equipment.*

LEACH RELAY CO.
Division of *Leach* CORPORATION
5915 Avalon Blvd., Los Angeles 3, California
Relays — Solenoids — Packaged Systems — Pressure Switches

PALMER ELECTRIC MFG. CO.
Subsidiary of *Leach* CORPORATION
6629 Bear Avenue, Bell, California
50-60-400 Cycle Alternators—Synchronous Motors—DC Generators

INET
Division of *Leach* CORPORATION
4441 Santa Fe Ave., Los Angeles 58, Calif.
Power Supplies — Rectifiers — Magnetic Amplifier Controls

JEFFRIES TRANSFORMER CO.
Subsidiary of *Leach* CORPORATION
1710 East 57th St., Los Angeles 58, Calif.
Transformers — Windings — Reactors — Toroids — Coils

Research
Development
Design
Production

Leach CORPORATION
5915 Avalon Blvd., Los Angeles 3, California
District Offices and Representatives in
Principal Cities of U. S. and Canada

FURNAS ELECTRIC

Magnetic Starters

Your most complete selection in the 1-50 hp range

NEW "IN-BETWEEN" SIZES SAVE ON COSTS AND UP TO 40% IN SPACE

Why Pay for Starter Capacity You Never Use? Now you can select the exact starter size matched to any application in the 1-50 hp range from the nine Furnas Electric sizes. Many in-between sizes can save you money and conserve space. Immediate delivery from stock.

Same Service, Less Money—Here's an example of how you can save: Suppose you want a starter for 10 hp service. It's no longer necessary to select a size 2 rated 25 hp. You save in cost and up to 40% in space by selecting a Furnas Electric type YE, the right starter for the job.

Important Features—1. Dual voltage coils matched to your motor. 2. Four-speed thermal overload protection. 3. Easy installation and wiring in shallow case. 4. Heavy contacts for long life.

Complete Range of Other Products—Pressure switches for air and water applications. Drum controllers for reversing, multi-speed and reversing multi-speed service.

Write today for Bulletin No. 5402, giving the full story. Furnas Electric Company, 1045 McKee Street, Batavia, Illinois.

FURNAS
ELECTRIC
Batavia, Illinois

Steel Corp., in announcing the new technique, noted that they are the first steel company to employ the method.

Inaudible sound waves are beamed into the metal samples. Echoes that rebound from the interior of the metal indicate flaws. In fact, Republic reports, both existence and location of flaws can be revealed.

Titanium will be checked ultrasonically for research purposes as well as in production.

Meetings and Expositions

Sept. 13-24—

Instrument Society of America. International instrument congress & exposition to be held at Convention Hall and Commercial Museum, Philadelphia, Pa. P. V. Jones Jr., 1319 Allegheny Ave., Pittsburgh, Pa., is secretary.

Sept. 21-23—

Society for Experimental Stress Analysis. Fall meeting and exhibit to be held at the Hotel Bellevue-Stratford, Philadelphia, Pa. W. M. Murray, P. O. Box 168, Cambridge 39, Massachusetts is secretary.

Sept. 27-30—

Society of Industrial Packaging & Materials Handling Engineers. Annual exposition to be held at the Coliseum, Chicago, Ill. Additional information may be obtained from society headquarters, 20 West Jackson Blvd., Chicago 4, Ill.

Sept. 28-Oct. 1—

Association of Iron & Steel Engineers. Annual convention and biennial exposition to be held at the Public Auditorium, Cleveland, O. T. J. Ess, 1010 Empire Bldg., Pittsburgh 22, Pa., is managing director.

Oct. 1-2—

Standards Engineers Society. Annual meeting to be held at Haddon Hall, Atlantic City, N. J. F. M. Oberlander, P. O. Box 281, Camden, N. J., is secretary.

Oct. 4-6—

National Electronics Conference. Tenth annual conference to be held at the Hotel Sherman, Chicago, Ill. Conference under the sponsorship of the American Institute of Electrical Engineers, Illinois Institute of Technology, Institute of Radio Engineers, Northwestern University. University of Illinois, with participation by the Radio Electronics Television Manufacturers Association, Society of Motion Picture & Television Engineers, Purdue University, and University of Wisconsin. R. E. Hornacek, N.E.C., Publicity Committee, 208 West Washington St., Chicago 6, Ill., is chairman.

Oct. 11-15—

American Institute of Electrical Engineers. Fall general meeting to be held at the Morrison Hotel, Chicago, Ill. H. H. Henline, 33 West 39th St., New York 18, N. Y., is secretary.

Oct. 24-27—

American Gear Manufacturers Association. Fall meeting to be held at the Edgewater Beach Hotel, Chicago, Ill. John C. Sears, One Thomas Circle, Washington 5, D. C., is executive secretary.

Nov. 1-5—

National Metal Congress & Exposition to be held at the International Amphitheatre, Chicago, Ill. W. H. Eisenman, 7301 Euclid Ave., Cleveland 3, O., is managing director.

Nov. 1-5—

American Welding Society. National fall meeting to be held at the Sherman Hotel, Chicago, Ill. Additional information may be obtained from society headquarters, 33 West 39th St., New York 18, N. Y.

MEN

OF MACHINES

The appointment of **Neal L. Cobb** as chief engineer has been announced by the Fellows Gear Shaper Co., Springfield, Vt. Mr. Cobb was educated at Tufts College and joined Fellows as a draftsman in 1926. After working in several sections of the engineering department, he was made head of the cutter design section. He was later appointed chief of tool design and held that position until his recent promotion. Mr. Cobb is a member of the American Gear Manufacturers Association and the Metal Cutting Institute.

Neal L. Cobb

Previously assistant director of engineering, **Richard L. Smirl** has been named director of engineering of Borg & Beck Div. of Borg-Warner Corp., Chicago.

The Radio Corp. of America has announced the appointment of **John L. Franke** as chief engineer, engineering department, of the RCA Victor Radio and Victrola Div., Camden, N. J. Concurrently, **Alexander D. Burt** was named manager of record changer engineering and **Paul R. Bennett** was appointed manager of radio and phonograph engineering. The three men were formerly staff engineers in the RCA Victor Home Instrument Div.

Paul A. Miller has joined Ford Motor Co. as manager, manufacturing-engineering, of the Parts and Equipment Div. in Ypsilanti, Mich. For the last 20 years Mr. Miller has been associated with the Leece-Neville Co., most recently as vice president.

Given Mfg. Co., Los Angeles, recently appointed **Dr. Clyde A. Crowley** director of the Development Engineering and Research Div. He will direct development engineering and research at the company's main plant in Los Angeles, as well as its research laboratory in Bethesda, Md.

Fred W. Emhardt has been appointed chief engineer of the Warren Div. of Struthers Wells Corp. in Warren, Pa. He has been with the firm since 1936.

The Midvale Co., Philadelphia, has announced the appointment of **Howard H. Casey** as director of engineering. His duties will include direction of engineering and research.

Two new engineering departments have been established by American Machine & Foundry Co., New York, to replace the former engineering department at Buffalo. **Robert L. Holloway** has been appointed chief engineer of the new

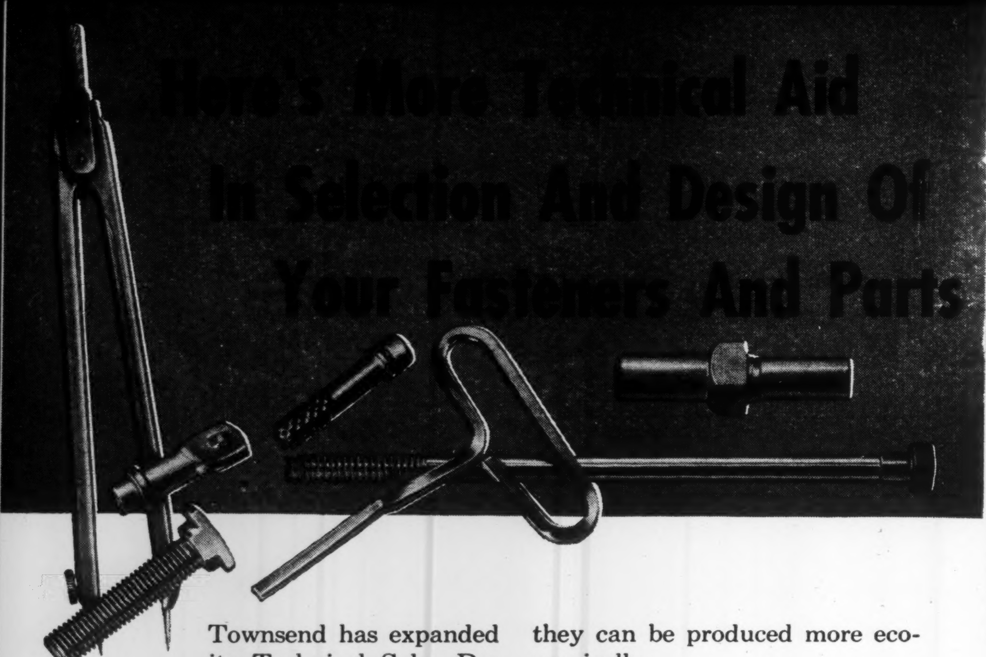
What does "S.B." mean to you?

To some, it means Salad Bowl and a French chef concocting a tasty dish. But, to hundreds of industrial designers, it means Small Balls ... the precisioneered kind Universal makes so accurately for smooth operation.

How small is small? Anything from the size of a pinhead up to you-name-it. Universal has special skills for making these perfect peewee pellets. Write for details.

Universal Ball co.

WILLOW GROVE
MONTGOMERY CO., PA.



Here's More Technical Aid In Selection And Design Of Your Fasteners And Parts

Townsend has expanded its Technical Sales Department to help you in your constant effort to improve your product, reduce unit costs and speed assembly. Here, a group of specialists works as a unit to devise the most economical and efficient methods of product assembly for all industry.

These men can serve you in several ways. They will visit your plant as fastening consultants to your design engineers and operating men. They will analyze a particular product and design special parts for it or suggest use of standard products in the assembly.

You may want them to study your entire production line for improved assembly techniques—they will even design a single part to solve a specific problem.

Another way to obtain the services of this department is to send drawings and samples of specific items for suggestions as to how they can be produced more economically.

Back of the Technical Sales Department is a company with nearly a century and a half of wire drawing and cold-forming experience. More than 10,000 standard and special parts and fasteners are produced regularly by Townsend.

In addition to the wide range of products and design experience at your command, Townsend has the tremendous capacity to produce 60-million pieces a day. This means you can depend upon Townsend to keep pace with your production lines since, in its several plants, there are enough machines of any type to handle a variety of long production runs simultaneously.

To learn how you may effect substantial savings in material costs, speed production and improve your product, write today for illustrated bulletin or use the coupon below.

THE FASTENING AUTHORITY
Townsend
COMPANY • ESTABLISHED 1816
NEW BRIGHTON, PENNSYLVANIA
Sales Offices in Principal Cities
Cherry Rivet Division • Santa Ana, California

In Canada: *Parmenter & Bulloch Manufacturing Company, Ltd., Gananoque, Ontario*

TOWNSEND COMPANY
Sales Department
New Brighton, Pa.

Please send Technical Sales Department Bulletin TL-98.

Name________ Title________
Company________
Street________
City________ Zone____ State____

Men of Machines

Advanced Engineering Dept. and **Herbert E. Oles** has been named chief engineer of the Buffalo Product Engineering Dept. Associated with AMF since 1946, Mr. Holloway was once manager of the Buffalo engineering department's special products and development section. Mr. Oles was formerly section manager of product engineering of the former Buffalo plant's engineering department.

O. S. McGuffey, who has had charge of research and development work in many phases of transport refrigeration for Tranter Mfg. Inc., Lansing, Mich., has been named chief engineer of the firm. He will direct all engineering activities for the Platecoil Div., where heat transfer equipment is manufactured, and the Kold-Hold Div., where refrigeration equipment is made. Mr. McGuffey first joined the company when it was founded as the Kold-Hold Co. in 1932. His engineering experience also includes several years of service with the Kelvinator Corp. in Detroit.

O. S. McGuffey

D. H. Apgar has been named technical engineer in production engineering by International Business Machines Corp., Endicott, N. Y. He joined the company in 1949 as a student in the engineering training program and was later assigned to research engineering. In 1951 he was transferred to production engineering as a designer.

The election of **Paul H. Taylor** as a director and vice president in charge of the Research and Hydra Spring divisions has been announced by Wales-Strippit Corp., North Tonawanda, N. Y. Mr. Taylor joined the company in 1945 and since that time has been director of patents and research.

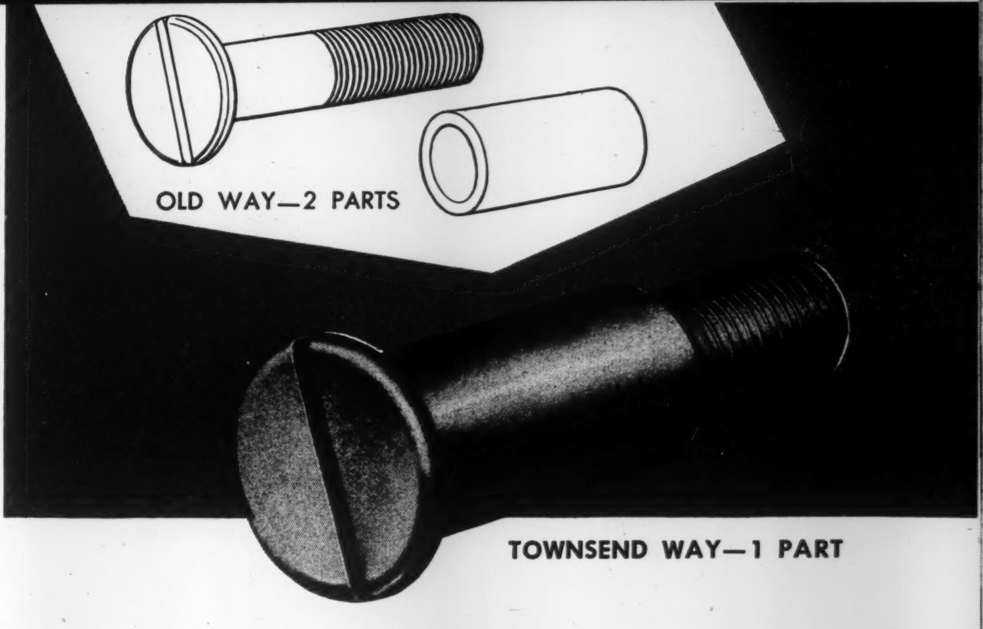
T. G. A. Sillers has been promoted to chief engineer of the switchgear department of Allis-Chalmers Mfg. Co., Milwaukee. He will continue to make his headquarters at the Hawley Works in West Allis, Wis. Replacing Mr. Sillers as assistant chief engineer of the switchgear department, **J. F. Chipman** will remain at the Boston Works, where he formerly served as engineer-in-charge of circuit breaker design. Mr. Sillers has been associated with Allis-Chalmers since 1926; Mr. Chipman, since 1936.

Mechanical Industries Inc., Pittsburg, has announced the appointment of **D. L. Edmunds** as chief engineer.

Carl W. Kalchthaler was recently appointed chief engineer of the Hyatt Bearings Div. of General Motors Corp. in Harrison, N. J. He succeeds **H. Ralston Gibbons,** who has been named technical assistant to the general manager.

Eaton Mfg. Co. has appointed **J. C. Sprague** engineering manager of its newly created aircraft division in Battle Creek, Mich.

The Aviation Gas Turbine Div. of Westinghouse Electric Corp., Philadelphia, has been reorganized into six new divisions. New managers of each department will report to **R. L. Wells,** assistant chief engineer of the division. **T. A. Daly** has been named to the newly



How One Townsend Part Does The Work Of Two

Combining the functions of two parts or more into a single cold-headed piece is a routine operation at Townsend. It's an operation that will help you simplify design, speed assembly and reduce inventory problems. This results in improved products and lower unit costs.

The bolt and sleeve above were assembled by hand and used to fasten a pulley in a household automatic clothes dryer. It was difficult to obtain a tight connection with the two pieces, which often resulted in excess vibration. Complaints and maintenance calls were numerous. The parts came from two suppliers which doubled the detail of purchasing and inventory control.

All of these problems were quickly solved by Townsend. The Technical Sales Department designed the single cold-headed part shown above which does the work of the two pieces. Assembly is speeded, purchasing and inventory control simplified. The biggest advantage, of course, is the tight, permanent connection achieved with the Townsend part, which eliminates a headache for manufacturer and dealer alike.

This is just one typical example of how the Townsend method of producing cold-formed parts and fasteners improves products and reduces unit costs for manufacturers in the appliance industry and other industries as well.

To learn quickly how Townsend, as "The Fastening Authority," will work with you to reduce assembly costs, ask to have an engineer call. For additional information, use the coupon below or write for illustrated bulletin.

Townsend
COMPANY • ESTABLISHED 1816

Sales Offices in Principal Cities

In Canada: *Parmenter & Bulloch Manufacturing Company, Ltd., Gananoque, Ontario*

TOWNSEND COMPANY
Sales Department
New Brighton, Pa.

Please send "Special Cold-Formed Fasteners and Small Parts" Bulletin TL-89.

Name__________ Title__________
Company__________
Street__________
City__________ Zone_____ State_____

STAINLESS STEEL FASTENINGS
by Anti-Corrosive

because

1 **SELECTION!** Anti-Corrosive has the widest range of stainless fastenings in the items, sizes and analyses *you want!*

2 **AVAILABILITY!** IN STOCK inventory of more than 9,000 varieties and sizes of stainless fastenings means *immediate delivery* of your needs! Streamlined service on special orders, too!

3 **LOWER COST!** Superior production capacity and know-how means *lower costs,* helps you stay within production budgets!

Write for FREE Product List 54E — lists complete range of items, sizes and analyses available from stock or by special order.

ANTI-CORROSIVE METAL PRODUCTS

ANTI-CORROSIVE
METAL PRODUCTS CO., INC.
Castleton-on-Hudson,
New York

created position of executive engineer. **G. W. Hardigg** will manage the advanced development division; **A. H. Redding,** the preliminary design division; **H. B. Saldin,** the development engine division; **P. G. DeHuff,** the production engine division. Mr. Daly will temporarily head the experimental operations divison, and **C. S. Cody** is manager of the administrative control and services division.

Associated with Convair since 1941, **K. J. Bossart** has been named an assistant chief engineer in the San Diego division of Convair Div. of General Dynamics Corp. He will be in charge of engineering for a guided missile project.

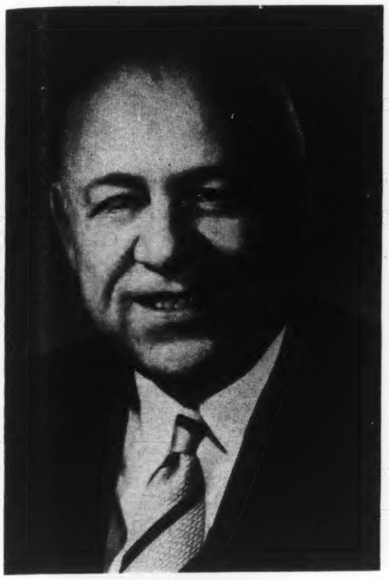
Austin E. Fribance was recently appointed chief engineer of Rochester Mfg. Co., Rochester, N. Y. He was formerly associated with Western Electric Co.

Don V. Slaker was recently named chief engineer of the dump car department of Baldwin-Lima-Hamilton Corp., Philadelphia.

Ernest E. Mankowski has been named chief engineer of Fresh'nd-Aire Div. of the Cory Corp., with headquarters at the division's appliance plant at Grayslake, Ill. He formerly served as air conditioning engineer for Coolerator Co.

Formerly chief engineer, **J. W. McMullen** has been promoted to the newly created position of vice president in charge of engineering of Lombard Corp., Youngstown.

Rear Adm. Louis Dreller, U. S. N. (Ret.), was recently named director of engineering of Brad Foote Gear Works Inc., Cicero, Ill., and its two subsidiaries, Pittsburgh Gear Co., Pittsburgh, and American Gear & Mfg. Co., Lemont, Ill. Adm. Dreller received a B. S. degree in engineering in 1918 from the University of New Hampshire and subsequently graduated from the U. S. Naval Academy Post Graduate School, received a mas-



Louis Dreller

ter's degree from Columbia University, and was awarded an honorary LL.D. from the University of New Hampshire. His duties in the Navy included those of production officer of the Philadelphia naval shipyard, during the building of the battleships New Jersey and Wisconsin, and design superintendent at the same location. He is a registered professional engineer in the District of Columbia and a past president of the American Society of Naval Engineers.

Formerly associated with the industrial engineering section of the General Electric Co., Schenectady, N. Y., **M. N. Halberg** has been named application engineer of the company's Large Motor and Generator Dept.

Frank L. LaQue has been elected vice president of the International Nickel Co. Inc. and manager of its Development and Research Div. He succeeds **Thomas H. Wickenden,** who has attained retirement age but will continue to serve the company as a consultant on special projects.

Director of engineering research and development, **Thurston Klayton** will also serve as chief engineer for Luria Engineering Co., New York.

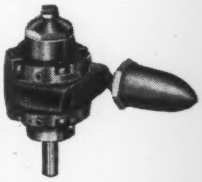
how 10 characteristics of
GAST
solve tough original equipment problems

Many a knotty power problem has been solved with Gast rotary Compressed Air Motors. Just one of these ten inherent advantages may make them ideal for your original equipment applications.

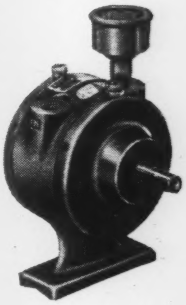
1 Much lower first cost.
2 Explosion-proof safety.
3 Variable speed over a wide range.
4 Can't burn out from over-loads or stalling.
5 Four vanes assure instant starting.
6 Amazing compactness for HP delivered.
7 Light weight—down to ¼ of equal electric motor.
8 Smooth-running rotary-vane performance.
9 Reversible models provide extra adaptability.
10 Dependability for long service—little maintenance.

Now standard equipment on such products as conveyors, hoists, agitators, textile machines, hose reels, liquid pump drives, etc., these versatile motors are available in four sizes and many design variations for vertical or horizontal drives with base or flange mountings.

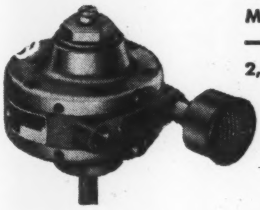
INVESTIGATE NOW—Gast engineers will gladly cooperate in arranging for tests on your application.



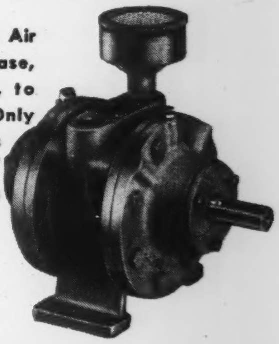
MODEL 1AM Air Motor with silencer —to ⅙ HP rec., to 6,000 RPM. Only 2½" x 4¼", weighs only 1½ lbs.



MODEL 4AM Air Motor with foot—to 1 HP, to 2,000 RPM. Only 5¾" high less muffler. Weighs approx. 8 lbs.



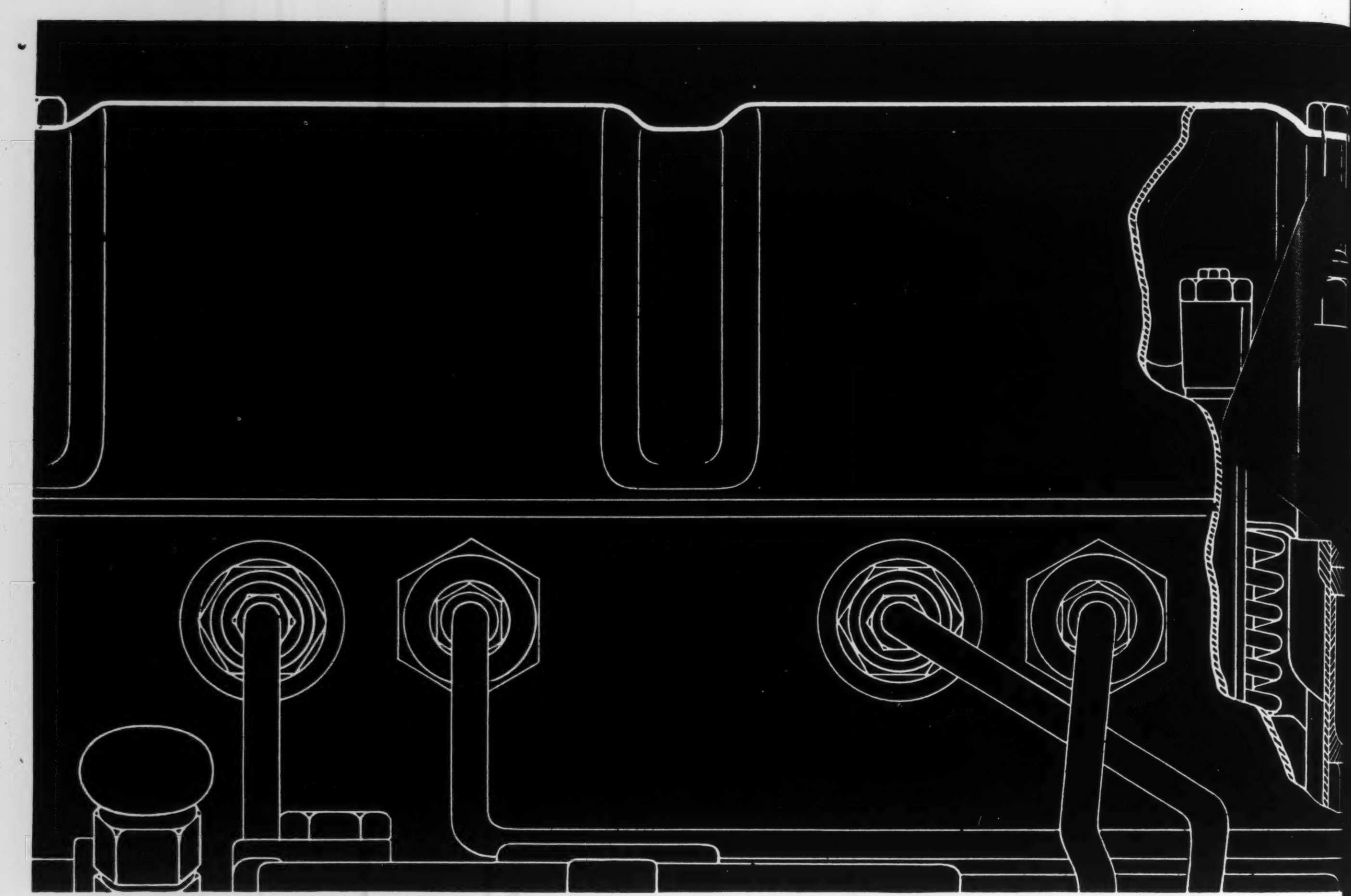
MODEL 2AM Air Motor with muffler — to ½ HP, to 2,000 RPM. Only 5½" high. Weighs approx. 5½ lbs.



MODEL 8AM Air Motor with base, — to 4 HP, to 1,500 RPM. Only 6½" high, less muffler, 8¼" long. Weighs 25 lbs.

Original Equipment Manufacturers for Over 25 Years

GAST ROTARY
(TO 4 H.P.) (TO 30 LBS.) (TO 28 INCHES)
GAST MANUFACTURING CORP., 107 Hinkley St., Benton Harbor, Mich.



improved fiber gasket seals perfectly with low bolt pressure

To seal a stamped flange under the low bolting pressures normally available requires a gasket with unusual compressibility.

The gasket for the stamped rocker lever cover on this diesel engine is a typical case. The original gasket leaked because it lacked compressibility and squeezed out of position on the narrow flange.

When the engine manufacturer switched to a brand-new fiber gasketing material—Armstrong's CN-705 Accopac®—the leaks stopped. Accopac—a unique combination of fiber, rubber, and cork—had the required compressibility. And surprisingly, it cost less than the material it replaced.

This superior performance results from the way Accopac is made. In a patented modification of the beater saturation process, cork particles, fiber, and rubber are literally locked together into strong, uniform sheets. The material is highly compressible, yet it resists crushing—Accopac compounds withstand test pressures up to 100,000 psi, while conventional top-grade fiber material often crushes under a load of 25,000 psi.

Gaskets cut from Accopac will not dry out, crack, or shrink in any recommended application. The latex binder is non-volatile and non-extractable. And because Accopac is virtually unaffected by variations in temperature and humidity, gaskets retain their dimensional stability even after months of storage.

Although it is a relatively new material, Accopac has had wide acceptance in hundreds of applications where a dependable, low-cost seal is needed. It is being used in pumps, engines, appliances, aircraft, automotive equipment, and a wide variety of industrial applications. Where can *you* use Accopac?

ARMSTRONG'S ACCOPAC

MACHINE DESIGN
SEPTEMBER 1954

Challenge for Tomorrow

TWENTY-FIVE years ago this month the first issue of MACHINE DESIGN was published. Feeling that our readers may share our indifference toward birthdays, especially other peoples', we don't intend to devote much space to talking about ourselves and our Silver Anniversary.

The occasion seems rather to call for a brief pause to salute the accomplishments of our readers, the design engineers whose practical vision has wrought such vast changes in our civilization in a seemingly brief quarter century.

With a few notable exceptions, the scientific principles upon which engineering developments still rest were known and had been applied in considerable degree by 1929. A Rip Van Winkle just awakened today from a twenty-five year sleep would first notice such differences as television, automatic home appliances, diesel locomotives, automatic production machinery, modern air transports, automobile transmissions, and elaborate computing machines. No spectacular new discoveries are involved here—just the results of persistent and often brilliant application and extension of known ideas and principles whose potentialities were either not fully recognized or were awaiting the deft touch of the design engineers, with a big assist from the metallurgists and chemists, to translate them into reality.

But what of the next quarter century? There come to mind, first, the potentialities of nuclear energy and other scientific principles which have recently advanced to a practical stage. But even without these and without possible radical discoveries as yet barely imagined it takes little effort to foresee changes even more significant than those which it has been our privilege to chronicle—and stimulate—in our first twenty-five years.

The previous quarter century, beginning in 1904, had seen such rapid developments, engineering and otherwise, that some influential people—not engineers—were saying in the early thirties that there were no new frontiers, America is completed, and so forth. Fortunately that kind of thinking does not seem to prevail today. Wherever we look we see jobs to be done, jobs that call for more mechanization, automation, and miniaturization, improved economy and performance, extensions of ideas into industry and the home and on the farm—in a word, jobs for the design engineer.

The design engineer has much more to work with today in the way of materials, engineered components and design techniques than in 1929. He has also gained considerable standing in his profession and in the eyes of management. His opportunities are better and more challenging than ever before. Twenty-five years hence we confidently expect to look back on a record of accomplishment that will completely eclipse that just completed.

Colin Carmichael
EDITOR

An industrial designer gives his views on successful co-ordination of . . .

INDUSTRIAL DESIGN and ENGINEERING DESIGN

By Peter Muller-Munk *Peter Muller-Munk Associates, Pittsburgh, Pa.*

OBJECTIVES of industrial design begin where the calculable ones of engineering cease. Where the design engineer concentrates on the mechanical, operational and performance characteristics of the product, the industrial designer applies himself to their acceptance and effect on the human being who, after all, will always remain the target of their joint efforts. No matter what the product is—a lathe, a refrigerator, a printing press or an electronic computer—in the end there are always human beings who will use and operate and react to what has been provided. It is the design engineer's responsibility to guarantee the product in terms of its operating and mechanical performance. It is the industrial designer's responsibility to guarantee their appreciation and understanding by the user.

To the industrial designer, the product is, hence, not yet complete in terms of its mechanical efficiency alone. Efficiency, usefulness, satisfaction are terms which have multiple meanings and requirements which go beyond the logic of engineering. Industrial designers consider appearance as the composite physical entity through which the user of a product reacts to its operation, function, safety, maintenance, price, color, size and endless other impressions which determine his approval or rejection. To say that engineering excellence is sufficient for the acceptance of a product, considering impulsive human reactions, would be like insisting that friendship, love and courage can be engineered and produced on the assembly line.

Based on this premise, industrial design is the balancing of all visual and physical factors which influence the impact of a product on its user and the emphasizing of those which are of the greatest consequence to the appreciation of its value. No matter how intricate the mechanism of a product, its appearance must prevent it from becoming frightening to the operator or purchaser. Its value here is simplicity of operation, and the industrial designer must convey this impression. On the other hand, if the value of a new machine lies in its arrangement of automatic controls, the industrial designer must focus attention and understanding on this feature. The concept of value is, therefore, not exclusively dependent on mechanical and engineering elements but on the readiness with which the physical appearance of a given product is assimilated by the purchaser and user. This ultimate physiognomy of a product is the responsibility of the industrial designer.

Less and less often can detailed understanding of the intricacies of engineered efficiency be depended upon, sometimes even on the part of our own management. The complexity of industrial apparatus and consumer products has today become so great that often few could understand it even if they tried. The industrial designer, therefore, attempts to convey the qualities of design engineering through the effect of its appearance. No matter how carefully considered the efficiency and quality of a machine have been, they will remain in doubt if its external appearance looks crude and accidental. Disposition of parting lines in castings, organization of controls, relation of machined surfaces to painted ones, juxtaposition of different materials—all combine to create certain immediate impressions which cannot be eradicated by any amount of verbal explanation. Control of these im-

Practical collaboration between design engineers and industrial designers requires clear understanding of mutual obligations, responsibilities, and areas of competence. Only by working together can the maximum potential of each be applied to creating an improved product. Here, a prominent industrial designer speaks his mind on this important—and often controversial—problem of establishing such a successful working arrangement.

Executive vice president of the Society of Industrial Designers, Mr. Muller-Munk has been active as an industrial design consultant for more than 25 years. He taught the first course leading to a degree in industrial design at Carnegie Institute of Technology. His industrial design experience covers a wide range of products—from appliances and cameras to machine tools.

pressions is again the concern of the industrial designer.

Specific information for products is usually first defined on paper, through working drawings, layouts and prints. This sign language of engineering determines the operational, mechanical and other characteristics and functions which later become tangible in the physical reality of the product. The engineer uses his drawings to determine the sequence of mechanical motions of apparatus and the sequence and type of manufacturing processes. The industrial designer, on the other hand, is called upon to project the visual identity of the engineering print in terms of size and form, of color, of comfort, of safety and accessibility, and of the composite of all details and subassemblies and their effect upon each other.

Much of our equipment has today often become so complicated that it can only be developed in steps progressing slowly from the solution of one part or assembly to another until they are finally connected and combined in one coherent structure.

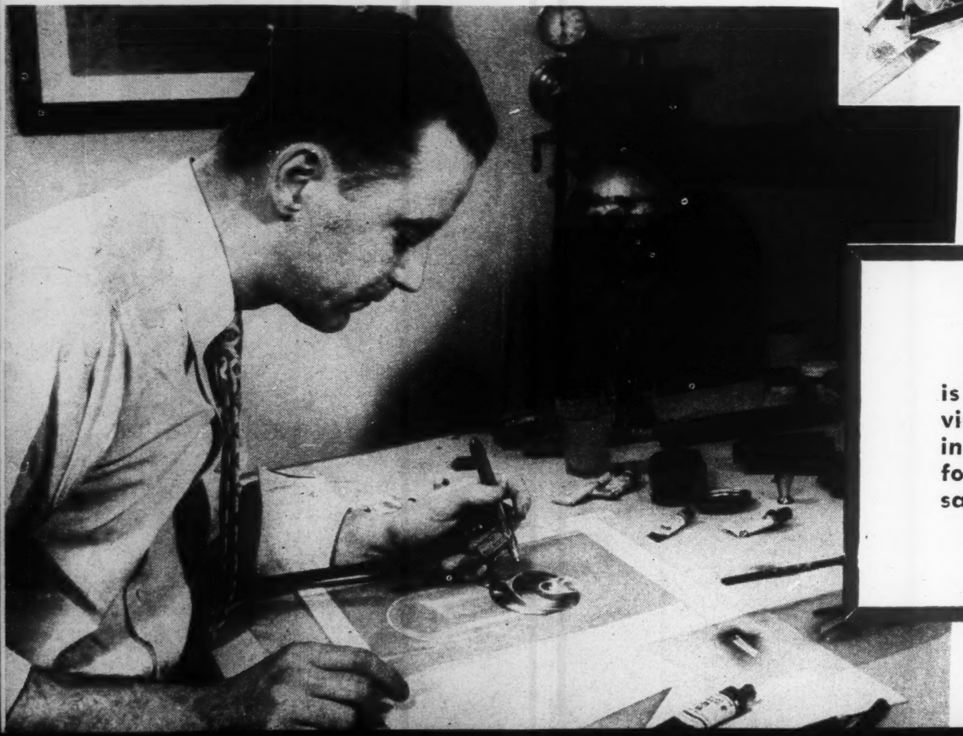
Like giant jigsaw puzzles, design of much of our modern equipment is a laborious process of isolated concentration and of highly specialized skills. It is the industrial designer's function to anticipate the effect of internal layouts on exterior appearance and the extent to which this will express to the user their original engineering intent. The industrial designer, therefore, attempts to provide a plan which assures orderly and coherent product character and most ready acceptance of its efficiency.

In order to accomplish this goal, the industrial designer assumes that he will receive from the engineer dependable rules for performance and endurance so that he can convey these convincingly to the user. Where the engineer is responsible for performance, the industrial designer is concerned with the *effect* of performance. Where the engineer determines the base costs of the product, the industrial designer is concerned with the *effect* of the product in relation to its ultimate price and vice versa. It is the role of the industrial designer to give the product character that expresses its inherent engineering function at its fullest and at its most economical.

While the general purpose of industrial design is today questioned only rarely, the opinion is still sometimes heard that the industrial designer's work consists of unnecessary additions to otherwise self-sufficient solutions. From this point of view, industrial design is an interference with, and a reflection on, the absolute authority of engineering dominance. Industrial design, however, is a cooperative effort. No honest industrial designer will be satisfied until he has convinced himself and the engineers he is working with that his suggestions can be accomplished within terms of mechanical and manufacturing economy. Revisions and alternatives proposed by industrial designers are always focused on the ultimate perfection of engineering specifications. As a matter of record, the industrial designer is often able to suggest refinements and practicalities which will act as insurance to the products of his engineering collaborators.

It is axiomatic that the industrial designer must be able to comprehend the language and objectives

. . . it is the role of the industrial designer to give the product character that expresses its inherent engineering function at its fullest . . .



. . . the industrial designer is called upon to project the visual identity of the engineering print in terms of size and form, of color, of comfort, of safety and accessibility . . .

of the engineer, that he must be able to read his prints and evaluate the principles of his calculations. In addition, he must instill the kind of confidence, born of actual achievements, which creates tolerance and understanding, and his personal and professional integrity must be unquestionable. The dividing line between the industrial designer and the design engineer is often very faint indeed, and for jointly developed projects it would be fallacious for either profession to claim full credit when it should be given to both.

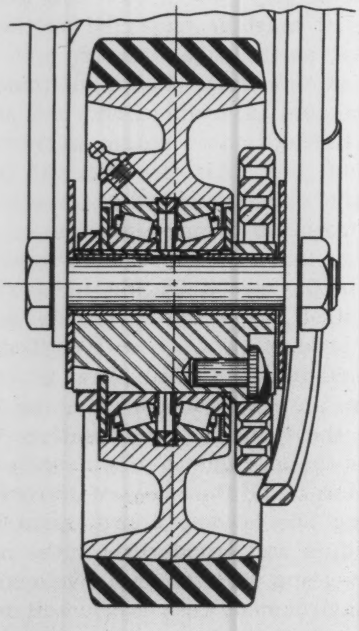
In order for industrial design to fulfill its function, however, it is of the greatest importance that engineering take the industrial designer into its confidence early, not after the structure of a project is already fixed. The industrial designer must be given the opportunity to work with engineering from the beginning so that he can contribute to the first concept of the product and not only to its last irreparable release just before production. The character and personality, the operation and cost of a product are determined very early—who should know that better than engineers—and it is precisely at that stage that the industrial designer can make his most significant contributions. By combining his views with that of engineering and production, all three have a chance to contribute the most without unnecessary compromise.

Only when industrial design is recognized on an equal level of importance with engineering and sales, will it be able to make contributions of equal importance. Before this can be accomplished, the industrial designer himself must, of course, have personal and professional status and maturity. It would hardly occur to company management to appoint a new, young graduate—no matter how promising—to the position of chief engineer. Is it not reasonable to assume that similar reservations are just as applicable to industrial design? If the industrial designer is to be of real help to the future of a company's products, his experience and competence must be assessed by the same standards that engineering and management would apply to themselves. Before industrial design can be effective, before it can perform its function, before it can be worth its pay—no matter how generous or how modest—it must be respected on the some professional level as its collaborators.

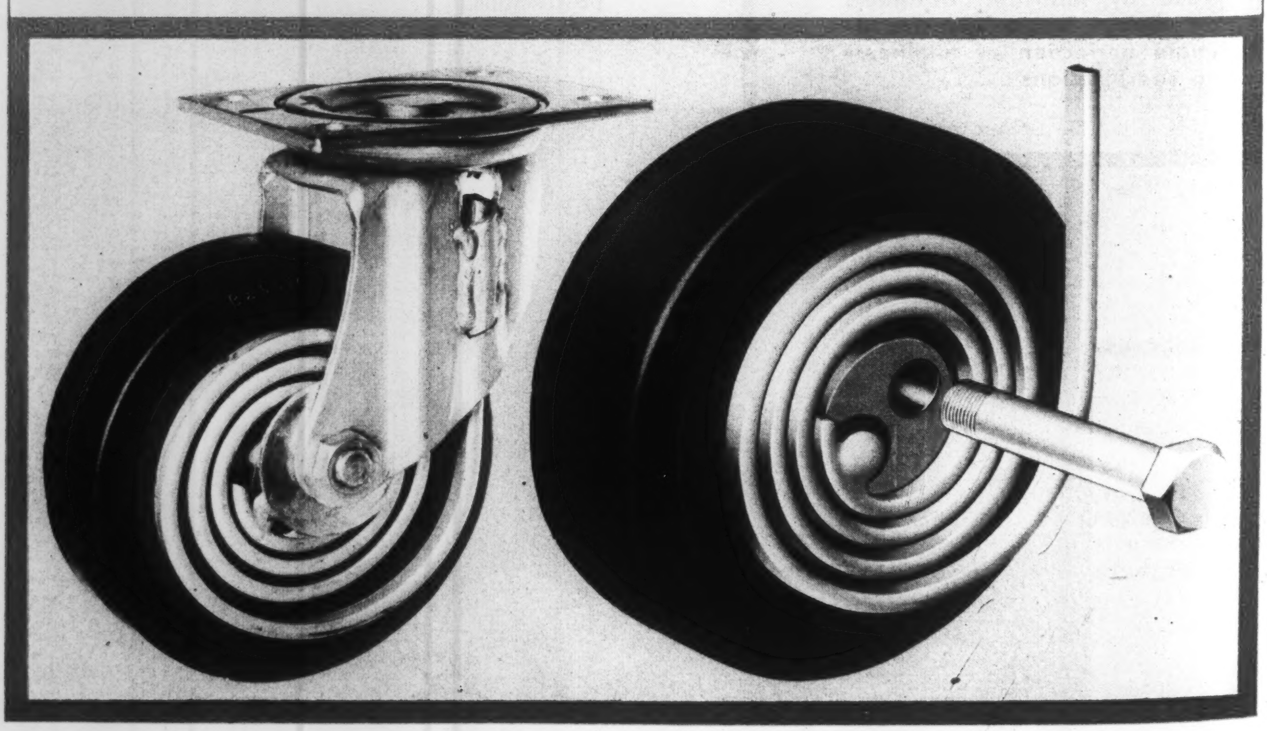
The relation of industrial design to industry is part of a logical and inevitable historical process. We have gone through three stages in our industrial development, and it is the last and present one which is the culmination of them all. First, we saw the transition from centuries of handcraftsmanship to mass production. From there, we progressed to the mechanization and perfection of the product itself, after the basic principles for its large-scale production were solved. Today we are moving ahead into the third phase of creative industrialization, an era in which man, the human being, is again the focus of our attention. We all realize that it is the machine that is meant to serve man and not man to be the slave of the machine. Industrial design has become a profession by developing techniques and standards for the humanization of engineering and for the development of an industrial environment that is a credit to both professions.

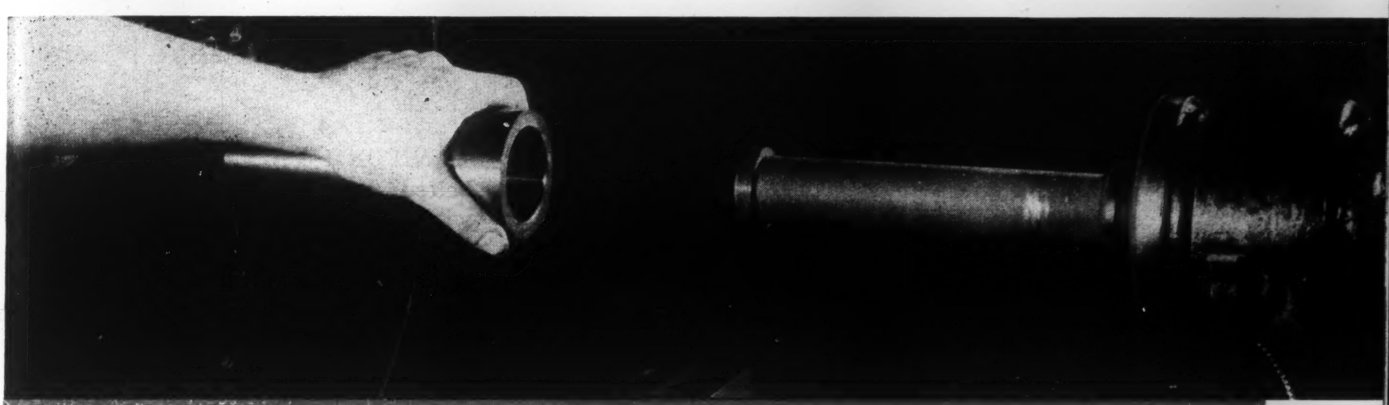
. . . industrial design is a co-operative effort . . . revisions and alternatives proposed by industrial designers are always focused on the ultimate perfection of engineering specifications . . .

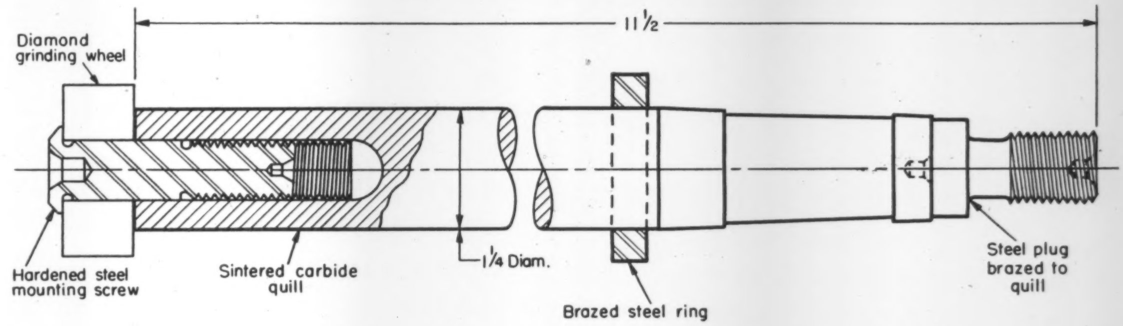
SCANNING the field for IDEAS



FLOATING HUB DESIGN in a wheel and caster construction developed by the Bassick Co. provides a compact rugged assembly capable of absorbing both horizontal and vertical shocks. Unlike conventional constructions, the hub is mounted to the carrier frame through a bolt axle which is offset from the center of the wheel; the outer wheel rotates on roller bearings on the outer surface of the hub. In operation, the hub is controlled by a flat spiral spring and pivots about the bolt axle, producing a rocking or "floating" action which absorbs shock and impact loads due to surface irregularities and permits the wheel to ride up or change position in the frame without altering the attitude of the carrier. Geometry of the design assures rapid deflection response and recovery on impact, producing a snubbing action for continued vibration and eliminating bounce and shimmy.



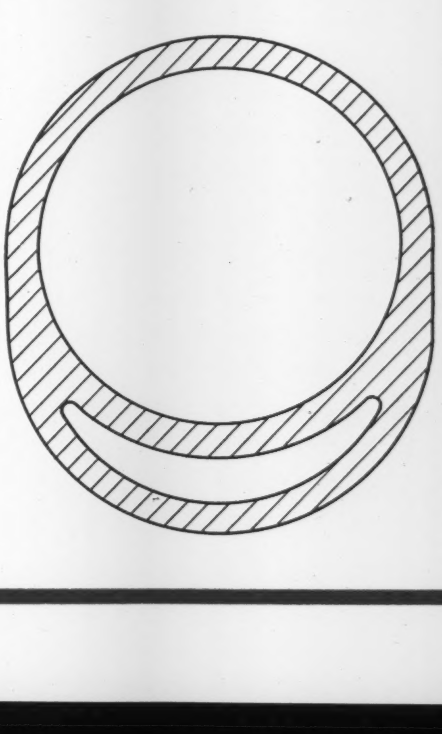


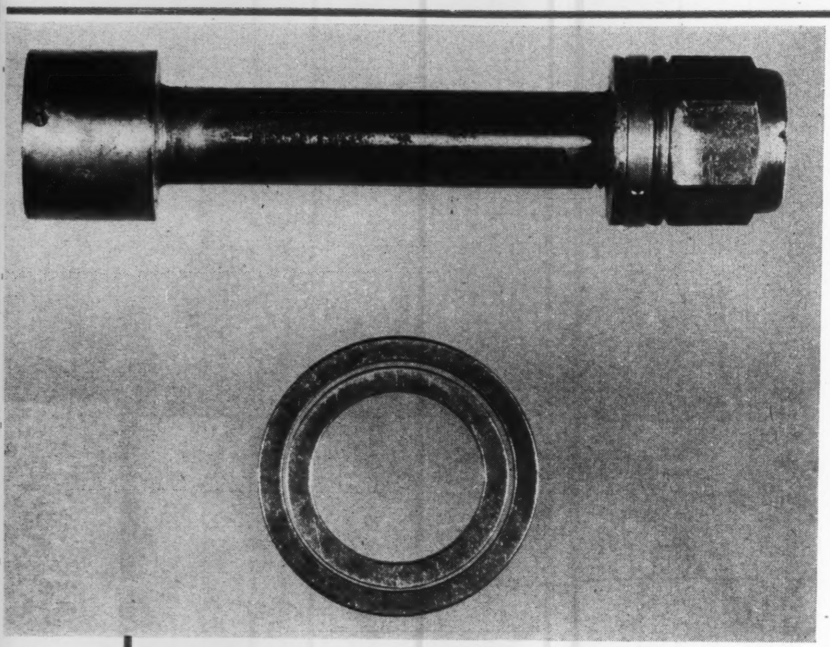


SINTERED-CARBIDE SHAFTS offer maximum stiffness under high static or dynamic bending loads. Providing a modulus of elasticity of 94,300,000 psi compared with 30,000,000 psi for steel, this material is especially suitable for small-diameter shaft applications operating under minimum deflection requirements.

A good example of the design possibilities offered is furnished by an overhanging grinding quill application in which a conventional steel quill was replaced by one of Kennametal K96 carbide. Deflection under load was decreased from 0.0075-inch to 0.0025-inch, reducing the tendency to whip and increasing the rate of stock removal.

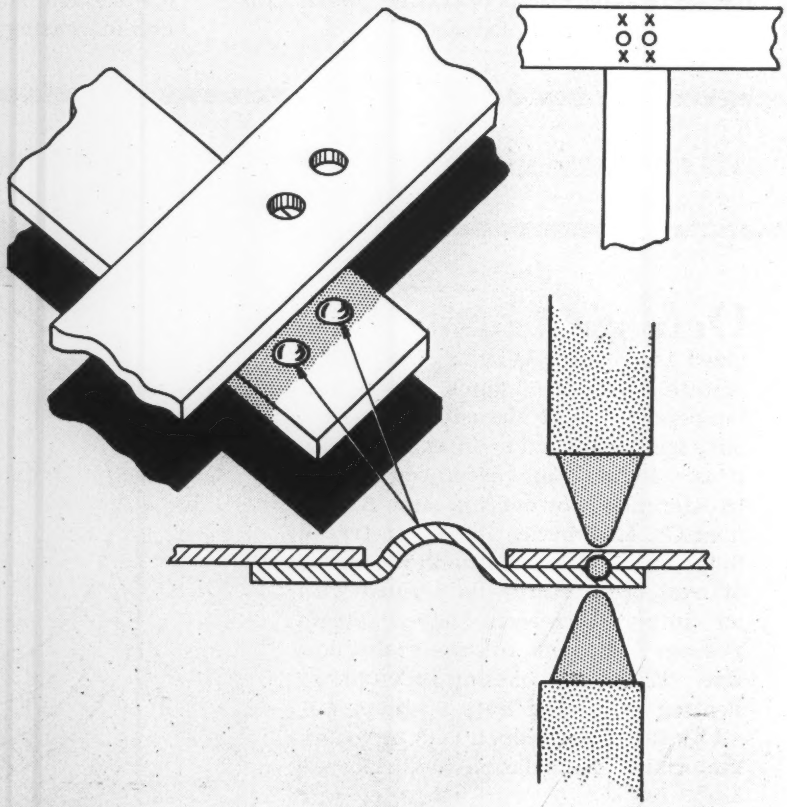
DUAL FLOW PASSAGES, combined in a single tubular section, facilitate handling of fluids at different temperatures and viscosities and simplify insulation and maintenance problems. In a design developed jointly by Hercules Powder Co. and Aluminum Co. of America for steam-traced fluid lines, extruded aluminum piping of oval cross section is formed with an integral crescent-shaped steam passage adjacent to the main flow line. External jacketing or auxiliary heating or cooling lines are eliminated by the design which acts to reduce material and insulation requirements.



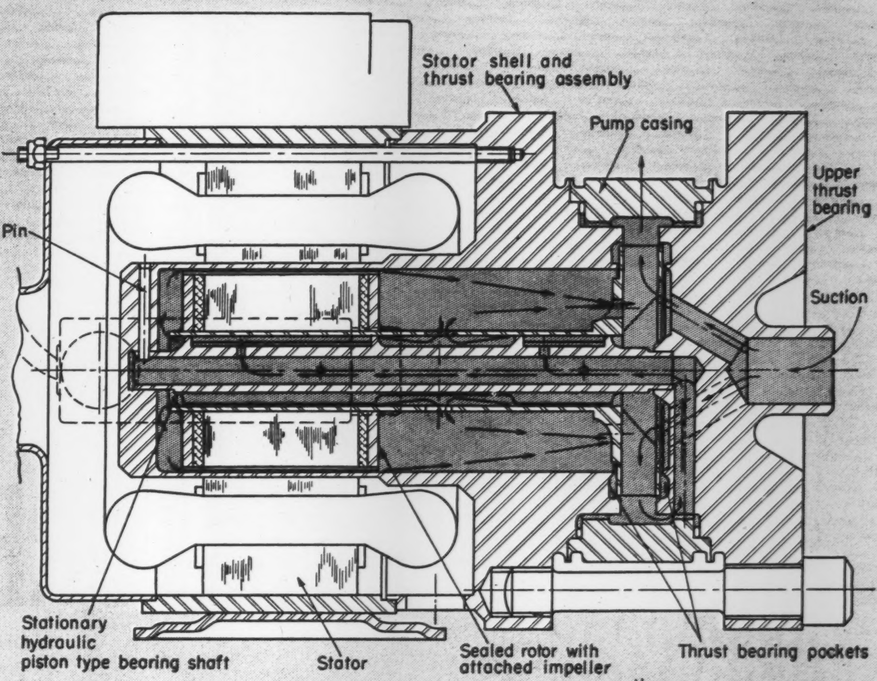


UNIFORM PRELOADING of bolted assemblies is obtained with a novel washer design employing two concentric metal rings. Developed by Douglas Aircraft Co., the washer permits accurate control over maximum preload and has an inner ring which is thicker than the loose-fitting outer ring. As the nut is tightened, the inner ring is compressed, producing a binding action between the two rings. When the outer ring can no longer be moved, the desired preload has been attained. Modification of washer dimensions and material permits variation of the load at which binding occurs. Need for torque wrenches is eliminated by the design which has produced consistent results under comprehensive test conditions; bolt tension preloads averaging 80 per cent of the desired value have been achieved regularly with only slight deviations.

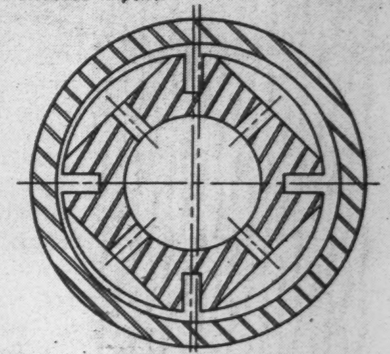
ACCURATE POSITIONING of overlapping parts for welded assembly is accomplished with an alignment technique developed by Cadillac Motor Car Div. of General Motors Corp. Angular shifting of adjacent parts in welding fixtures, due to normal size variations within tolerance requirements, is eliminated through the use of twin cone-shaped impressions on one part and matching holes on the other. When pressed together, the parts align automatically in the correct position, simplifying the welding operation and reducing the possibility of human error.



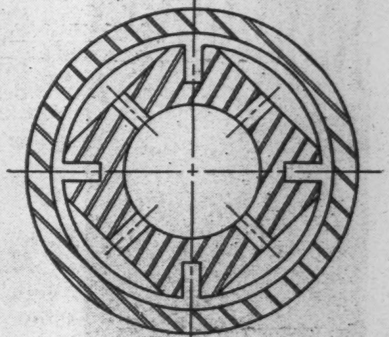
IDEAS


Stator shell and thrust bearing assembly
Pump casing
Upper thrust bearing
Suction
Pin
Stationary hydraulic piston type bearing shaft
Stator
Sealed rotor with attached impeller
Thrust bearing pockets

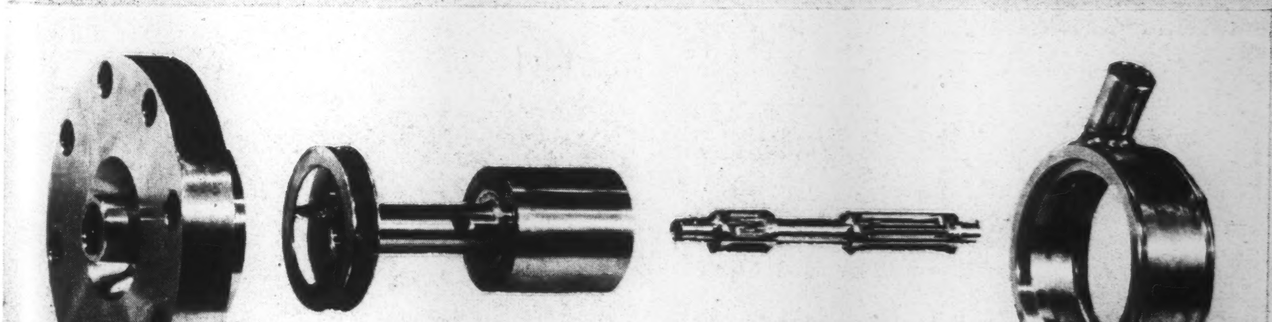
FLUID PISTON BEARINGS for rotating shaft assemblies offer high radial load capacity and eliminate the need for precision surfaces or selective material combinations. Designed for use on a hermetically-sealed pumping unit, the bearings developed by Allis-Chalmers Mfg. Co. consist of milled pockets, or pistons, spaced circumferentially around a hollow shaft mounted in a rotating tubular housing. Fluid under pressure flows into the pockets from the shaft interior through an orifice in the shaft wall and leaves through a clearance space between the shaft and housing; the fluid in the passage acts to "float" the tube concentric to the shaft. Pressure source is usually the main pump impeller or a second impeller on the same shaft, however, external pressure sources have also been successfully employed in a modified form of the design. Radial movements of the housing under load affect the fluid flow through the orifices, creating a pressure differential across the pockets and producing a restoring force which tends to recenter the tubular housing. Although subject to metal-to-metal contact during starting and stopping, the bearings have been successfully operated under extended intermittent running conditions without difficulty; effectiveness is not impaired by scratches or other surface irregularities, as contrasted with conventional hydrodynamic sleeve bearings. Suitable for low or high-temperature applications, the bearings can be employed with fluids such as water, kerosene, mercury, sodium, etc., and, in addition, permit the use of nonconventional bearing metals such as stainless steel.

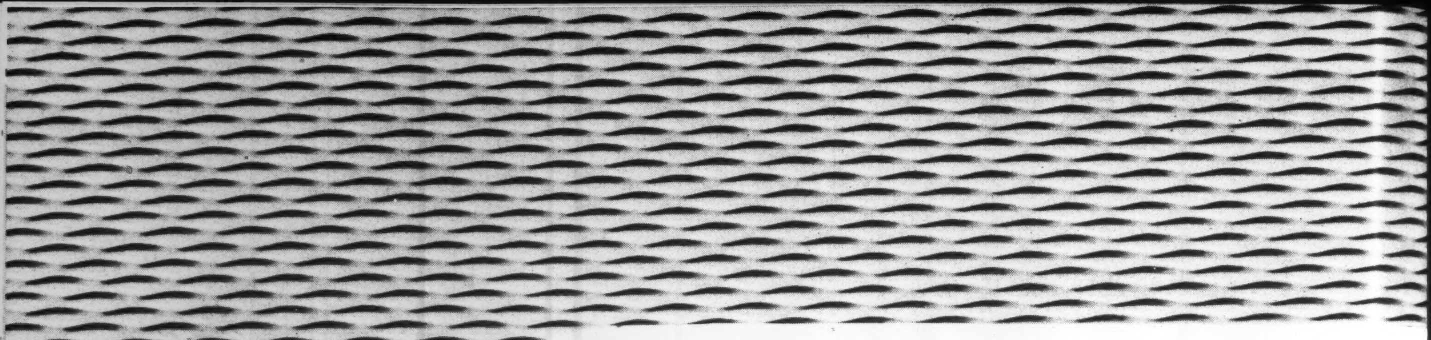


Unbalanced Load



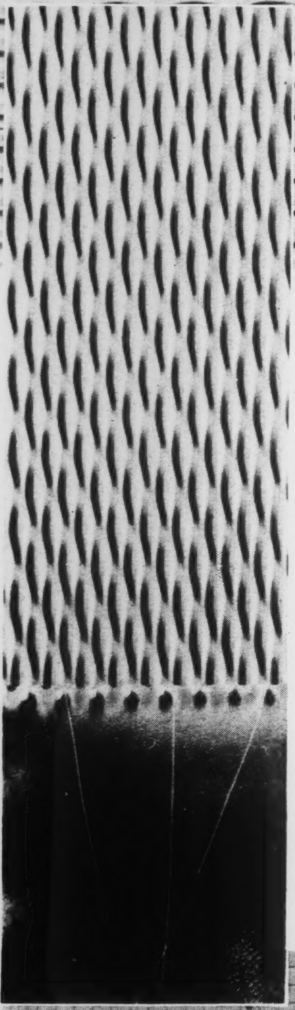
Balanced Load





Designing with TEXTURED METALS

By Joseph J. Clement
Rigidized Metals Corp.
Industrial Designer
Buffalo, N. Y.

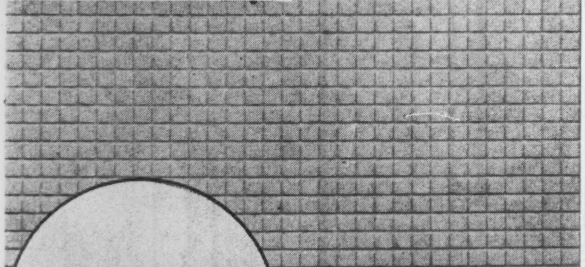


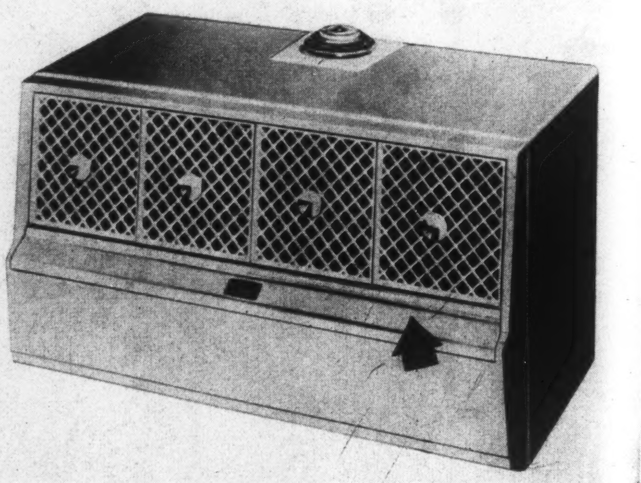
Test panel combining textured and plain sheet demonstrates "hiding" of fingerprints, scratches and dents inherent with textured metals

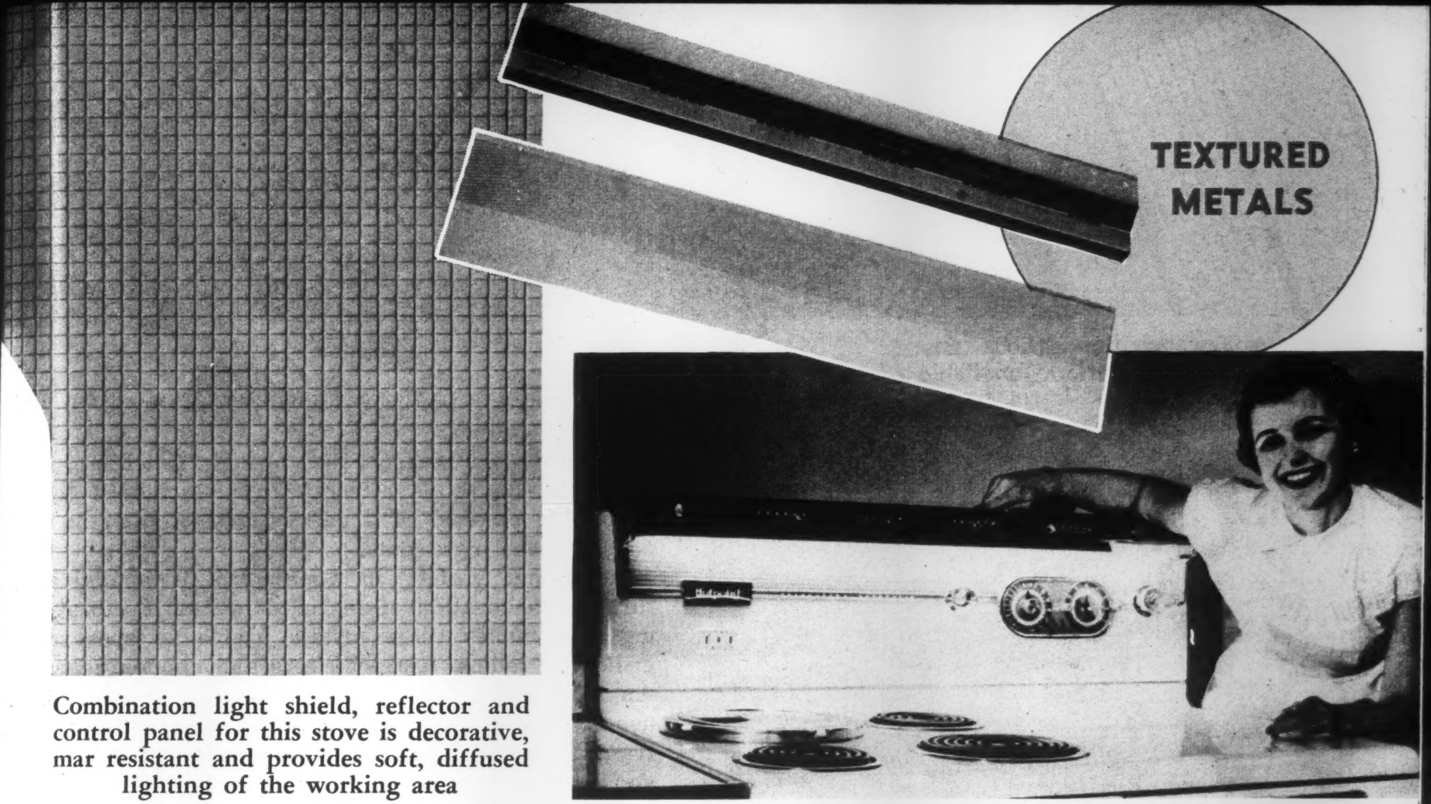
ATTRACTIVE appearance of textured metals is probably their one universally recognized characteristic. However, there are certain other properties of textured or "rigidized" metals which make their use as purely structural materials attractive to the designer.

As implied by the term "rigidized," one of these characteristics is the rigidity imparted to metallic sheet by the deformation which occurs during the texture rolling process. This rigidity or strength permits use of lighter-gage metals than would ordinarily be required in many instances, and can re-

Small-square patterned trim plate adds a decorative touch to this room air-conditioner. Made of aluminum, the plate is anodized in a rich gold color. Appearance and mar resistance were the prime factors in selection of this pattern







Combination light shield, reflector and control panel for this stove is decorative, mar resistant and provides soft, diffused lighting of the working area

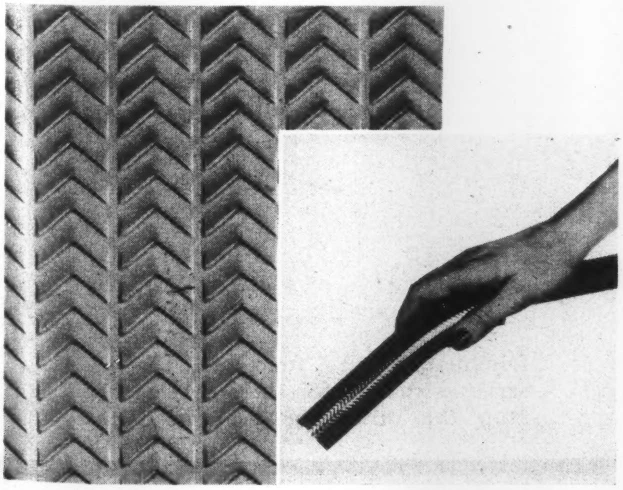
sult in weight savings of as much as 100 per cent.

Increased surface area also results in superior heat transfer characteristics because of the larger radiating surface. Several patterns have been specifically designed for maximum heat transfer properties.

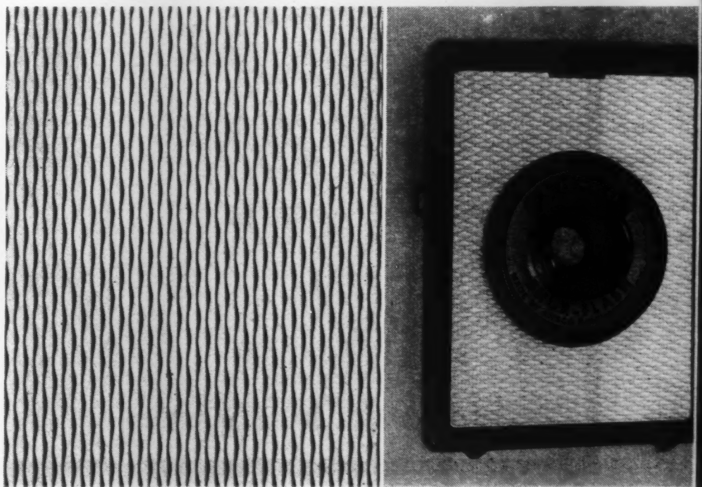
Another of the not immediately apparent properties of textured metals is their ability to maintain good appearance. Because the surface is patterned, and light is highly diffused when reflected, dents, scratches and fingerprints are not as obvious as they would be on a smooth, flat surface. This applies, of course, to newly manufactured products as well as those which have seen service.

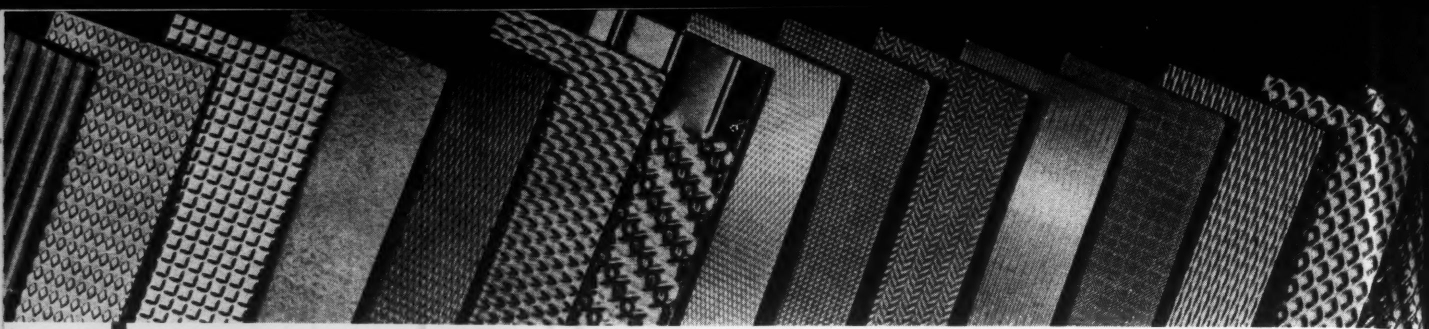
Patterns and Metals Available: Almost any flat-rolled metal such as aluminum, brass, copper, stainless or carbon steel can be textured. Designs of many kinds, both large and small, can be rolled into these metals. Straight lines, square, diamond, circular, triangular or hexagonal patterns with depths ranging from 0.003 to 0.320-inch are available. Special designs incorporating product identifying marks are also possible. Patterns com-

Tubular vacuum cleaner wand of chrome-plated, herringbone-textured carbon steel provides more positive locking of assembled sections. Additionally, scuff marks and scratches picked up during manufacture do not show after plating, eliminating rejects

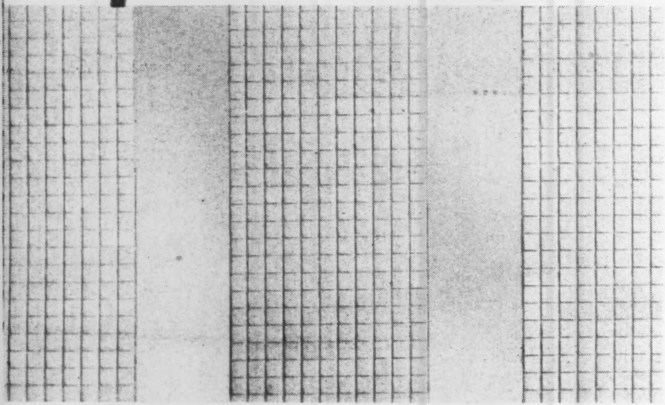


Camera puts its best face forward with face plate of textured metal. Strength, rigidity and dimensional stability, as well as appearance, are important in this application

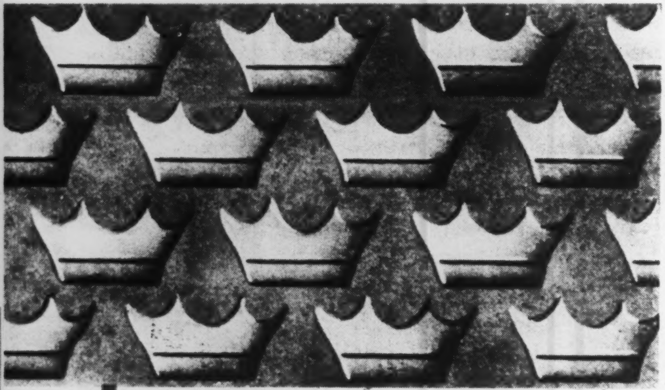




A few of the various textured metal patterns available



Pattern with alternate textured and plain areas combines pleasing appearance with space for embossed instructions or designations of control buttons and knobs



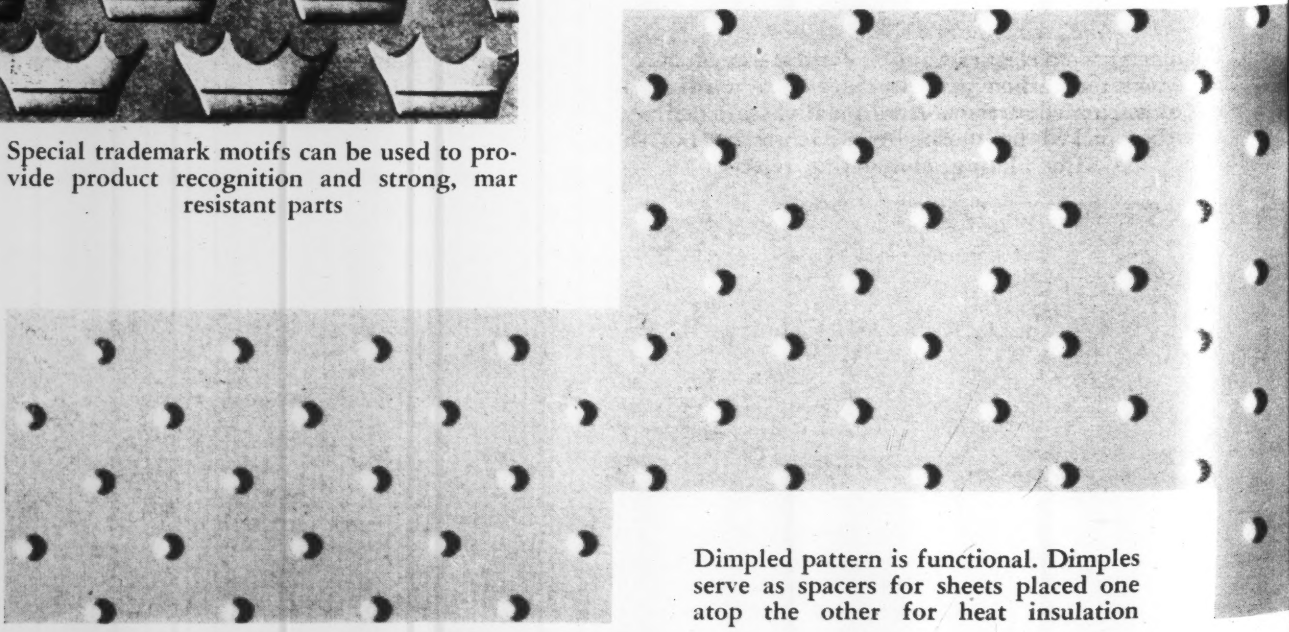
Special trademark motifs can be used to provide product recognition and strong, mar resistant parts

bining striped, textured and/or plain areas are other possibilities.

Anodized, oxidized, polished or satin finishes can be used. Two-tone effects can be achieved by filling the recesses of a pattern with a color and polishing the high spots.

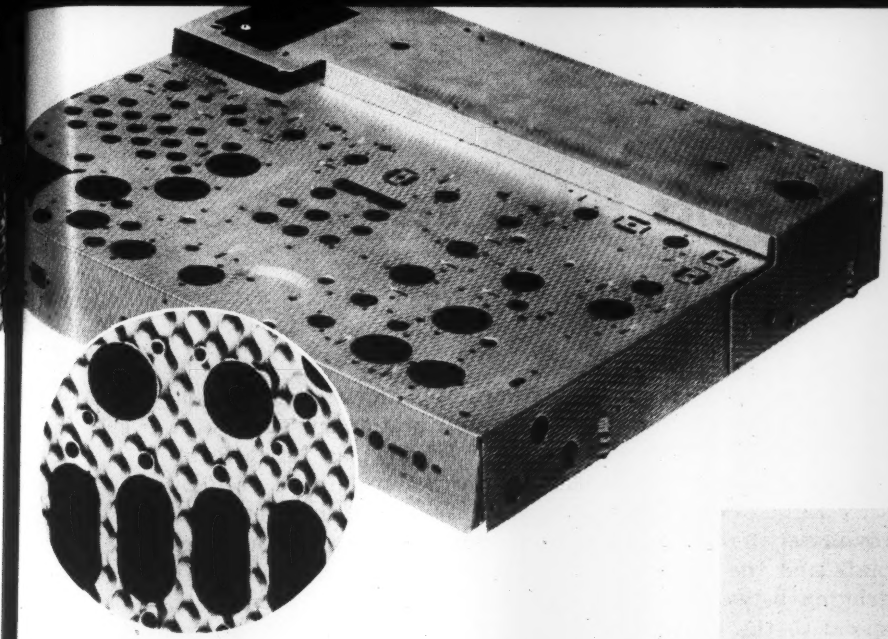
Additional variety in appearance is available through perforation of textured metals. Perforating also makes these metals usable as speaker grilles on radios, television sets and phonographs. An 18 per cent opening has been found to be usually sufficient to provide excellent sound transmission. The perforated metals also make good sound deadeners; either alone or as a decorative covering for acoustical felt or glass fiber.

Designing for Production: Textured metals can be formed and fabricated by methods used with ordinary sheet metals. They can be sheared, blanked, punched, drawn and stamped. Riveting, soldering, arc welding, spot welding, atomic hydrogen welding or adhesive bonding as well as conventional threaded fasteners may be used for joining textured metals. Only two precautions are in order. When joining seams, the pattern should be matched for appearance sake. When draws deeper than 1 inch are made, some distortion of the pattern will result. If the distortion is not objectionable, deeper draws can be made.



Dimpled pattern is functional. Dimples serve as spacers for sheets placed one atop the other for heat insulation

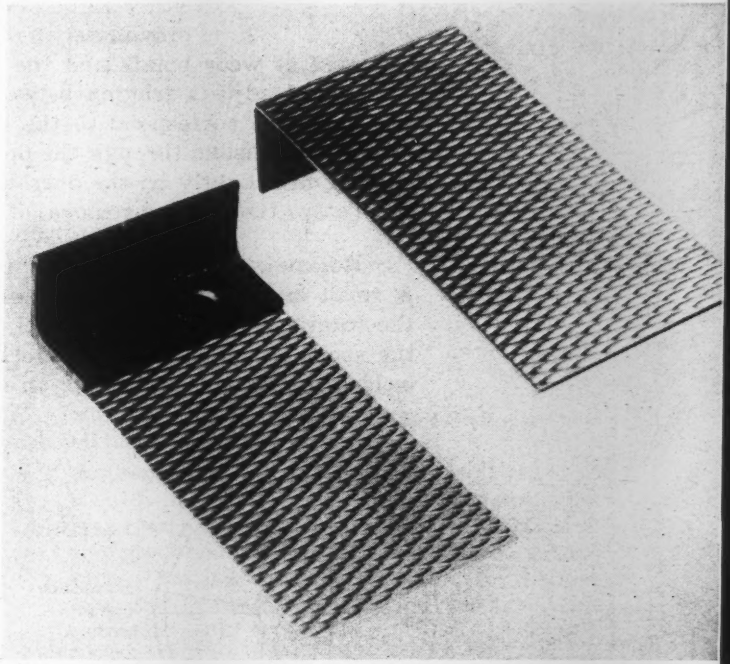
TEXTURED METALS



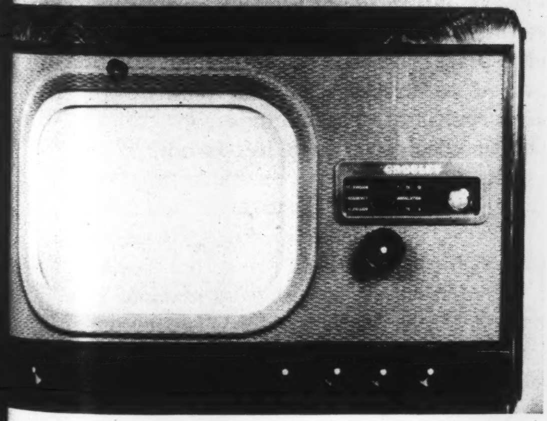
Conventional fabricating methods were used to blank, stamp, punch, form and weld this television chassis. Light weight, rigidity and excellent heat-radiating properties of textured metals are considerations in selecting textured metal for this application

MISSOURI
PACIFIC
LINES

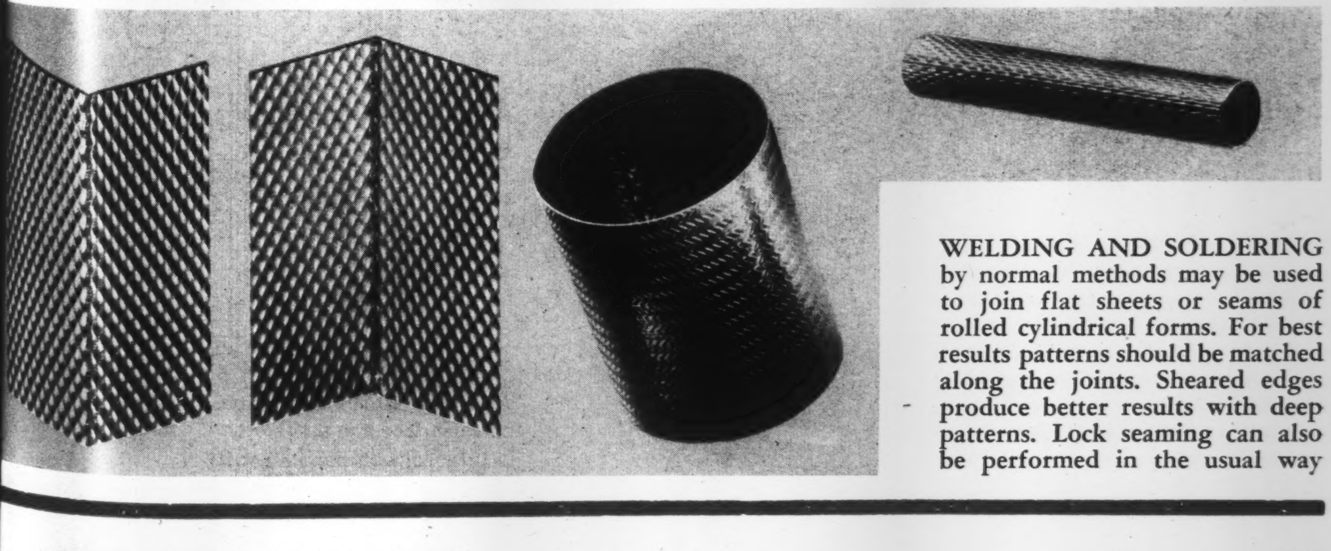
RIVETED by conventional procedure, this shipping container of textured metal retains structural strength and weighs 53 per cent less than similar container of flat sheet



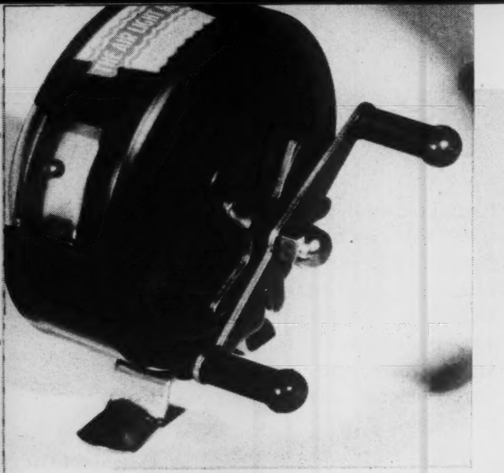
SPOT-WELDED to an angle, this piece of textured metal shows no marring from clamping between the welding electrodes. Copper wire braid placed between electrode and textured metal formed a nest to eliminate pattern distortion



PERFORATED AND DRAWN textured metal grille. No pattern distortion of textured metals occurs with draws to 1 inch in depth. Greater depths are possible if moderate distortion is not objectionable



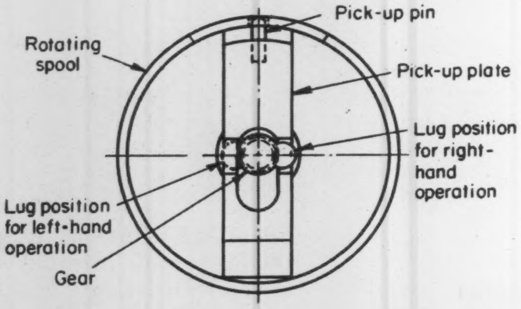
WELDING AND SOLDERING by normal methods may be used to join flat sheets or seams of rolled cylindrical forms. For best results patterns should be matched along the joints. Sheared edges produce better results with deep patterns. Lock seaming can also be performed in the usual way



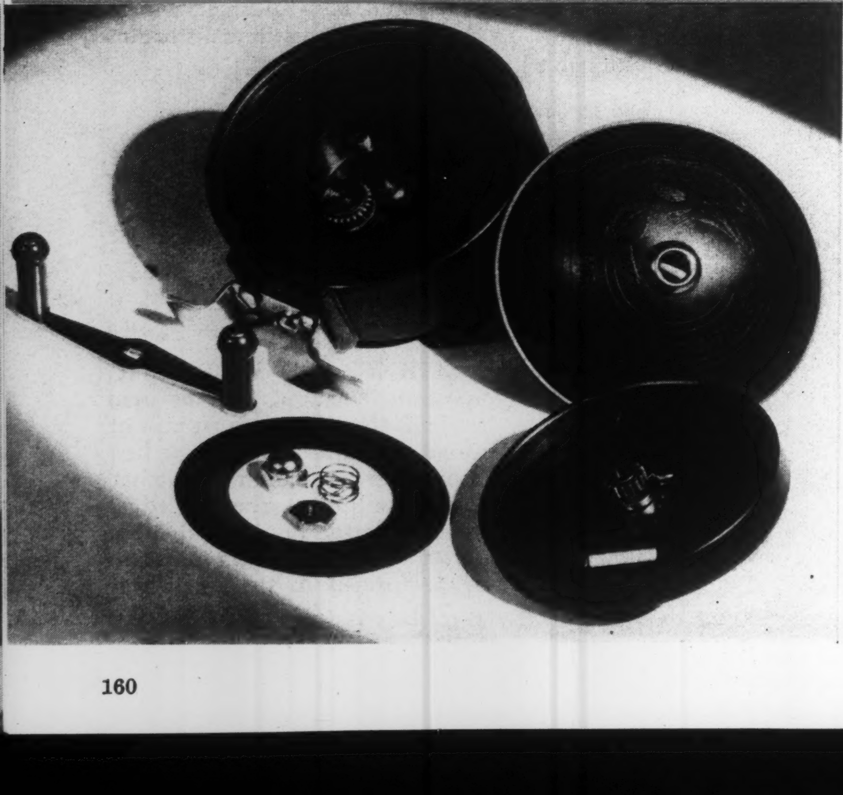
Plastics Fishing Reel Is Ambidextrous

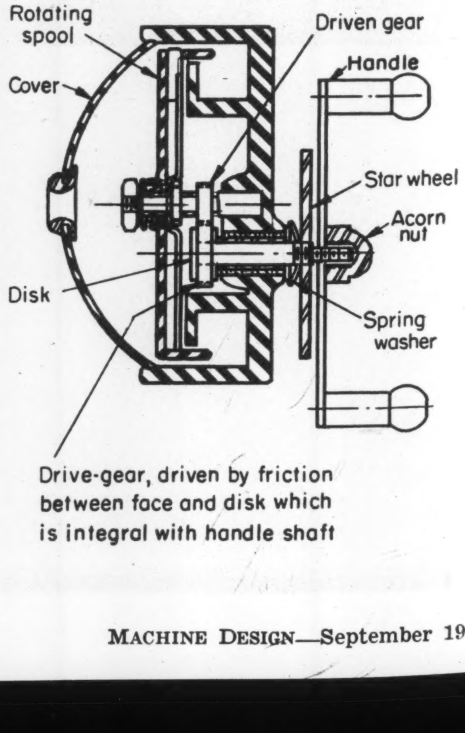
HIGH-impact Bakelite polystyrene plastic is used to mold reel cap, rotating spool case and stationary spool of a low-cost spinning and casting reel made by Air Light Products Co. A simple adjustment allows the reel to be used by either right or left-handed persons. Weight of the reel is approximately 5 ounces. Molded-in metal grommets and bushings are used at wear points and the rotating spool revolves on a molded-in shaft. Star wheel adjusts friction between the handle shaft and spool-drive gear and can be set to correspond to the breaking strength of the line being used. The pick-up pin, visible through the opening in the case, is retracted when casting by backing off slightly on the operating handle. Placing the thumb on the rotating spool stops the line and removal of the thumb releases it.

Rotating spool is driven by two to one ratio gears for retrieving the line. A small lug splined to a sleeve on which the driven gear is also splined drives the rotating spool through a pick-up plate which is free to slide in its recess in the spool for about 1/8-inch before it starts to drive the spool. The pick-up pin welded to the end of the pick-up plate is either extended or retracted by sliding of the plate. Removal of the cover, which is semiflexible and snaps into a groove in the main housing, gives access to a nut which holds rotating spool and pick-up plate on the shaft. Pulling out the gear and lug and reversing the position of the lug in the pick-up plate reverses direction of rotation required to extend the pin, pick up the line and reel it in. This change converts the reel to either right or left-hand operation.

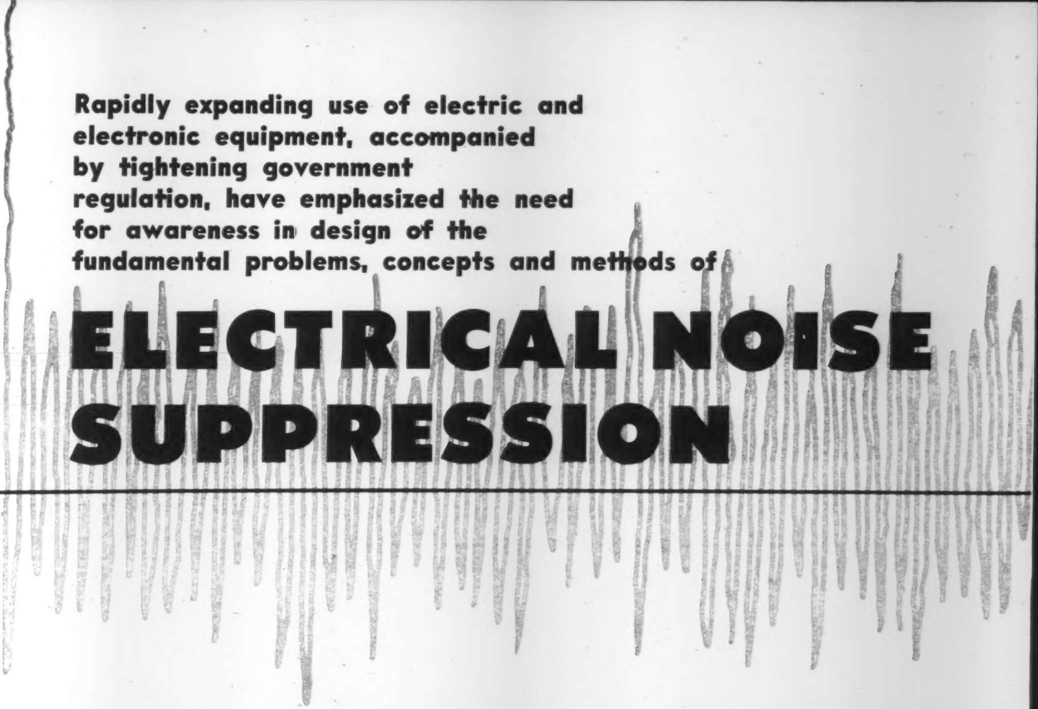

Pick-up pin
Rotating spool
Pick-up plate
Lug position for right-hand operation
Lug position for left-hand operation
Gear

CONTEMPORARY DESIGN




Rotating spool
Driven gear
Handle
Cover
Star wheel
Acorn nut
Disk
Spring washer
Drive-gear, driven by friction between face and disk which is integral with handle shaft

Rapidly expanding use of electric and electronic equipment, accompanied by tightening government regulation, have emphasized the need for awareness in design of the fundamental problems, concepts and methods of



ELECTRICAL NOISE SUPPRESSION

By M. B. Ewalt
Tobe Deutschmann Corp.
Norwood, Mass.

INTERFERENCE suppression is necessary if maximum reliability and efficient operation of commercial and military electronic installations are to be attained and maintained. Of secondary importance, but nevertheless of considerable concern, is the nuisance value of the interference which may take any form from a minor click of a light switch heard in a radio receiver to a distorted picture on the television screen, often occurring during the most popular programs.

Electrical noise or, as it is sometimes called, radio interference may be defined as conducted or radiated electric or electronic disturbances which cause an undesirable condition in, or incorrect functioning of, electronic equipment. The equipment could be a radar unit, a navigational instrument, a communication receiver, a broadcast receiver or a television receiver in which both audio and visual presentation are affected.

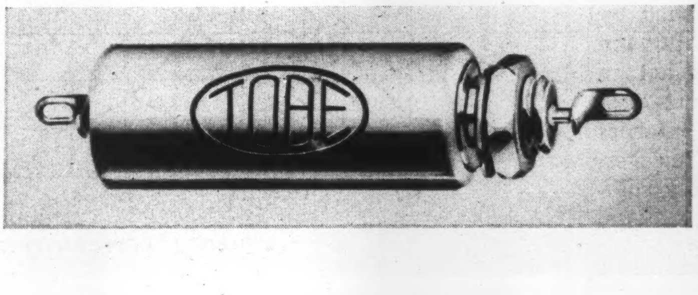
Electrical noise is always associated with a varying electric or magnetic field and may be produced by rotating machinery in which electrical variations occur each time the brushes pass from one commutator segment to the next, mechanical switching in electrical control circuits, arcing, nonlinear impedances, variation in impedances, oscillators, amplifiers, modulators, pulse generators and other vacuum tube devices. If devices generating electrical noise are located in the vicinity of receiving equipment, interference will be experienced when these devices are being operated. Interference may result from conduction or radiation. The most prolific sources are listed in *Table* 1.

Electrical noise suppression is needed when:

1. Radio frequency energy, generated at any frequency in the radio spectrum other than the authorized frequency, interferes with radio communication services.
2. Radio frequency energy, generated at any frequency in the radio spectrum, is conducted over the associated power lines of equipment and produces a signal in excess of 10 microvolts when measured at a distance of 50 feet from the power line at a point one mile from the equipment.
3. Electric or electronic equipment operating in conjunction with other equipment adversely affects the performance of that equipment.

FCC Regulations (Part 18) and Department of Defense Agencies specifications such as MIL-I-17623, MIL-I-6181-B and MIL-I-16910 are specific as to suppression requirements. These references also contain data about measurements and limitations.

Design Approach: There are many methods of suppression in general use. Each device has its own particular application, but on occasions many have been used indiscriminately to remedy a condition without considering the possibility that inter-



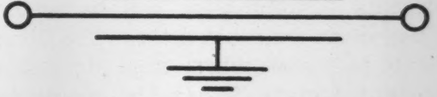


Fig. 1—Typical feed-through suppression capacitor and basic circuit diagram of the device, which is useful for filtering power-supply and control - circuit conductors

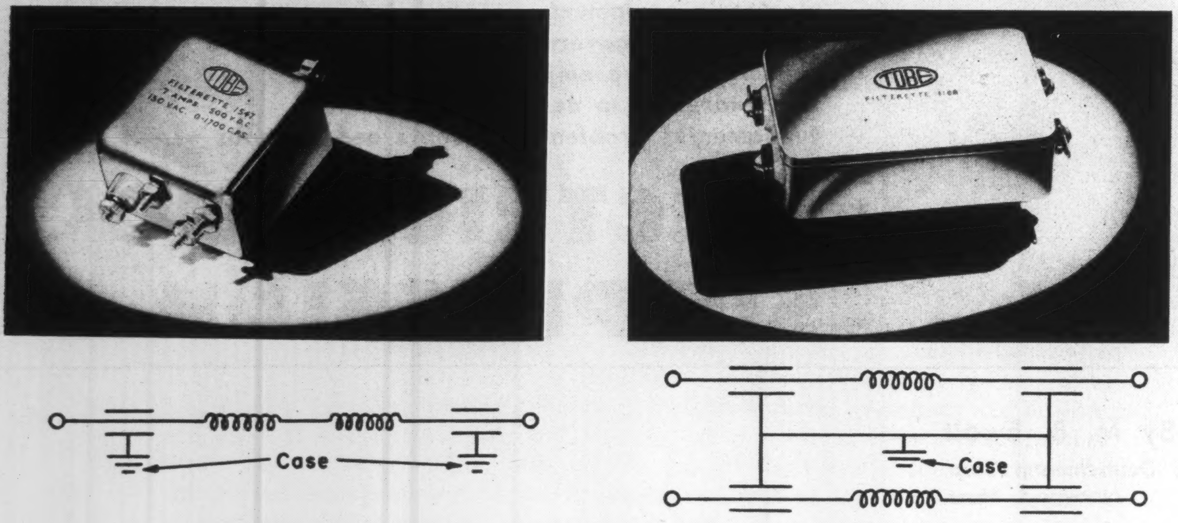


Fig. 2—Typical inductive-capacitor filters and basic circuit diagrams for, left, single-circuit type and, right, dual-circuit type. Single circuit types are used where a single conductor is involved; dual circuit types are used when two conductors, usually a distribution circuit, are being filtered

ference may have been moved to another frequency. This is more or less a trial and error method which disregards scientific aspects. There is an explanation, however, which offers a logical basis for this procedure: Magnitude of interference and frequency or frequencies at which the interference is present can only be assumed, unless adequate measuring equipment is readily available and is used to determine these factors.

The logical approach to suppression of electrical noise in equipment which has reached production stages is to conduct a thorough interference survey, utilizing approved types of measuring instruments. This survey should seek to establish the magnitude of interference, the frequency range and the location of components in which the interference is generated. If the source is an oscillator operating in the high frequencies, the chances are that it will not interfere at low frequencies. If it is a low-frequency oscillator, it may cause interference at the lower end of the frequency spectrum and at higher frequencies through harmonics of the fundamental.

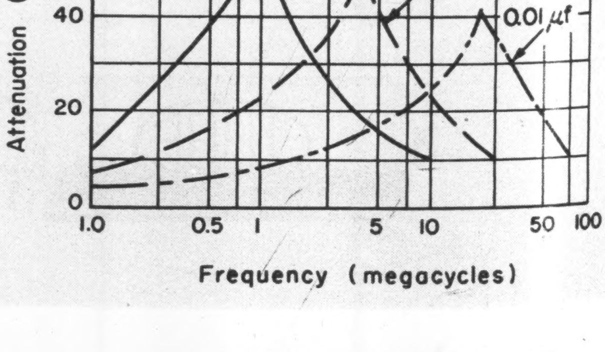
Some universal motors cause interference from 10 kilocycles to well above 1000 megacycles. Peaking may occur at any point but is usually maximum at from 100 kilocycles to 50 megacycles, with magnitude in some cases reaching many hundred microvolts. Suppression can be accomplished by the use of an external filter. The filter is not too difficult to install when space limitation is not an important factor. When the motor is part of a portable tool or an appliance, however, the external filter is cumbersome regardless of size. However, external suppression techniques are the only solution at present.

Methods of Suppression: The four most common

Table 1—Common Sources of Electrical Noise

Source	Nature of Interference	Range	Suppression Data
Ignition systems of motor vehicles and gasoline driven auxiliary equipment	Radiated	1250 ft	Shield ignition harness and capacitors.
Fluorescent lamps	Radiated Conducted	15 ft 100 ft	Line filters.
Motors	Radiated Conducted	Variable Variable	Install power line filters.
Neon signs	Conducted	1000 ft	Install power line filters. Eliminate twisted conductor terminals. Use shielded conductors with shield well bonded.
High-voltage transmission lines	Radiated	Miles	Caused by corona discharge. Increase insulator size. Install rain shields to reduce conductivity path during bad weather conditions.
High-frequency industrial equipment	Radiated	Miles	Shield equipment completely. Filter power lines.

Fig. 3 — Frequency attenuation characteristics for three typical conventional capacitors



methods of noise suppression are: (1) Noninductive capacitors, (2) feed-through suppression capacitors, (3) filters and (4) application of electronic principles.

NONINDUCTIVE CAPACITORS: These capacitors have limited application. Selection of a condenser is based on a capacitance value giving a resonant frequency at or near the peak frequency at which maximum attenuation of interference is desired. Multiple-circuit attenuation is possible by the use of a single container having any number of individual capacitors.

FEED-THROUGH SUPPRESSION CAPACITORS: Electrically, these capacitors are three-terminal devices which have a through lead connected in series with the line to be filtered and a grounded case, *Fig.* 1. Construction is such that cancellation of the major part of inductance normally present in capacitors of the best construction is accomplished. These capacitors are especially useful as filters for power-supply and control-circuit conductors going to shielded high-frequency equipment. Maximum filtering effectiveness, by minimizing mutual inductance between input interference source and output terminal, is possible when feed-through suppression capacitors are mounted in such a way that the leads being filtered pass through a shield, bulkhead or chassis.

FILTERS: For these applications, the degree of attenuation should be determined. This value can be readily found from the expression

$$A = 20 \log \frac{V}{S}$$

where A = required attenuation, decibels; V = interference RF voltage, microvolts; and S = receiver sensitivity, microvolts.

For example, if it were known that an interference RF voltage of approximately 100,000 microvolts were being conducted in the power line of a receiver having a sensitivity of 10 microvolts and it was desired to prevent interference from the source and provide a signal-to-noise ratio of 6 decibels, the attenuation required of the filter for the power line is,

$$A = 20 \log \left(\frac{100{,}000}{10} \right) = 20 \log 10^4$$

$$= 80 \text{ db}$$

Adding 6 db for the signal-to-noise ratio gives the total attenuation required: 86 decibels. Thus, the proposed filter must provide greater than 86 decibels in the frequency range of the interference voltages.

Filters can be designed in both simple and complex networks, *Fig.* 2. Units providing attenuation of 100 decibels of interference between the frequencies of 10 kilocycles and 1000 megacycles are offered by manufacturers.

APPLICATION OF ELECTRONIC PRINCIPLES: In radio-frequency industrial heating equipment and other electronic devices, design features often require analytical review. Because of the wide range of operating frequencies and the variety of applications, each problem must be considered individually. However, considerations common to all include separation of interconnecting cables by shielding and bonding to ground; separation of stages by shielding; suppression on interconnecting circuits between oscillators, amplifiers, modulators and final stages; and filtering of voltage circuits, motors, servos and other components of the equipment which may be a source of interference generation.

The purpose of shielding is to prevent interaction of electric and/or magnetic fields between equipment components. This objective is usually accomplished by placing a metal housing around the component and/or conductor to separate them from each other or from other similar parts with which they are closely associated. Generally speaking, when shielding is used, primary concern will be with confining or restricting the magnetic, elec-

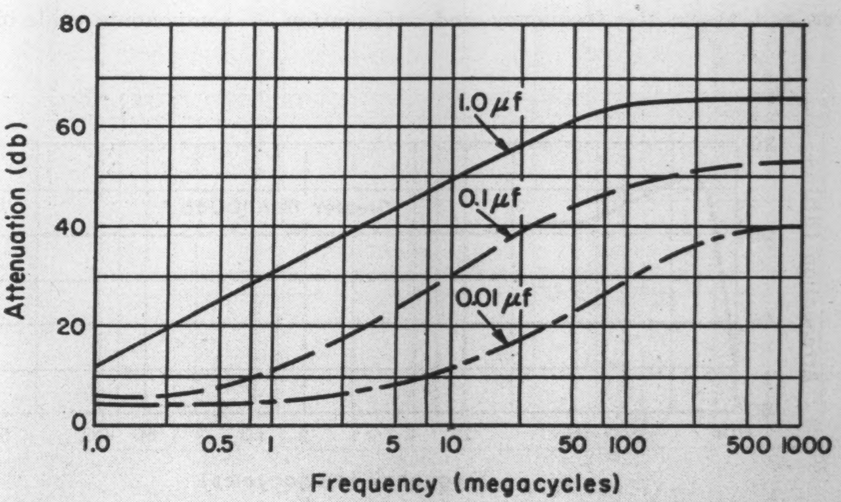


Fig. 4—Frequency attenuation characteristics for three feed-through suppression capacitors of the same capacitance as the conventional types of *Fig.* 3

tric or electromagnetic field to the limits of a particular area.

Radiation theory and induction theory are commonly accepted as the basis for shielding action. In the case of the radiation theory, the shield acts as a reflector and also attenuates the energy passing through the shielding medium. The energy, in the process of striking the metal shielding surface, is attenuated by reflection and the remainder is greatly attenuated while passing through the metal. That part which passes through the shield is then reflected back toward the source with a reduction during the reflection process. Because of this action it can be seen that thickness and composition of shielding material are important considerations in obtaining maximum attenuation of reflection from the shield, losses during conduction and residual radiated energy, to a point where interference could not constitute a serious source for further suppression.

In the case of induction theory, the interference currents and voltages set up interference fields surrounding the conductor. These fields are composed of electromagnetic waves of interference energy which induce current in the shielding surrounding the conductor. With a perfect shield the fields set up by the shield currents are 180 degrees out of phase with the conductor fields and cancellation results.

A perfect shield is one that would have no resistive content in its composition. Since there is no perfect conductor, the shielding materials selected are those with the smallest amount of resistance, such as silver, copper and aluminum.

Application Characteristics: Effective frequency and attenuation characteristics of typical 0.01, 0.1 and 1.0 microfarad conventional capacitors are shown in *Fig.* 3. In *Fig.* 4, the attenuation normally provided by use of feed-through suppression capacitors of similar values is indicated. The curve in *Fig.* 5 shows the attenuation of a filter designed for broad frequency coverage. The illustration of electronic principles suggests too many possibilities for complete coverage here; however, it should not be too difficult to visualize the requirements when the basic considerations are known.

Over and above the frequency and attenuation characteristics, the choice of a filter for a specific application must also be governed by the following requirements:

1. Current and voltage limitations.
2. Temperature, humidity and other environmental requirements.
3. Space and weight limitations.
4. Voltage drop.
5. Auxiliary factors, such as maximum capacity to the container, insulation resistance and maximum test voltages.

General Design Criteria: In selecting a method of suppression for a particular application, the following considerations should be given careful attention in design analysis.

1. *Consideration of the entire equipment as a single network or source of interference.* The interference generated during the sequence of operation may be intermittent or continuous and from single or multiple components.

2. *Magnitude of total interference radiated into space with respect to a reference level, the frequency and the coverage in the frequency spectrum.* These values in terms of standard units of microvolts/meter/kilocycle bandwidth (peak) are obtained by the use of measuring instruments with frequency ranges between 15 kilocycles and 1000 megacycles. There are many types and models of these instruments available, some approved by government agencies, others being tested for performance and classification. Curve 1 of *Fig.* 6 represents the limits of permissible radiated interference allowed by MIL-I-16910 (Ships) specifications. When these limits are exceeded, suppression is necessary.

3. *Magnitude of total interference conducted over associated power supply lines and interconnecting cables with respect to a reference level, the frequency and the coverage in the frequency spectrum.* These values are also expressed in terms of standard units; permissible conducted interference is assimilated on Curve 1 of *Fig.* 7.

4. *Source of interference.* This may be a click from a switch, commutation from motors, RF oscillators, harmonics, etc. Separate levels of interference are obtained by operating individual components while others are disconnected or placed

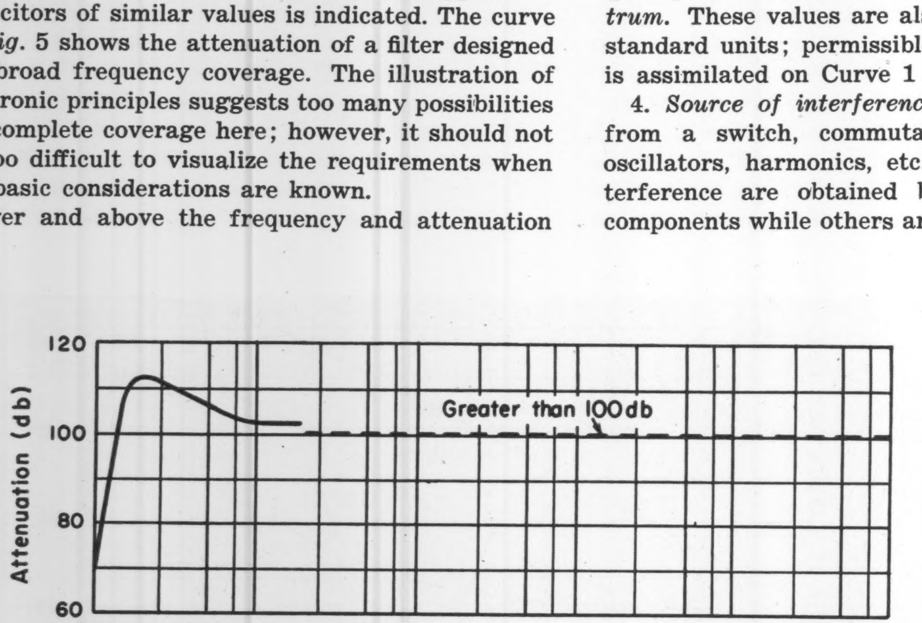


Fig. 5—Frequency attenuation characteristics for a typical inductive-capacitor filter

in an inoperative state.

5. *Approximate impedance level of line into which suppression device is to be inserted.* Normally, feed-through suppression capacitors and filters are designed and tested to work into a 50-ohm line. Allowances must be made and performance requirements calculated when the actual impedance differs from this value.

6. *Upper and lower levels of cut-off frequencies to be suppressed or stopped, and need for high or low-pass filters.* For example, high-pass suppression filters attenuate all frequencies from zero to cut-off and pass all frequencies above the cut-off point. If the cut-off frequency is 40 megacycles, all frequencies above this value would pass and all interference at frequencies below this value would be attenuated. Low-pass filters pass all frequencies from zero to cut-off and reject all frequencies above the cut-off point. If it is desired to pass 60-cycles power and reject radio noise above 100 kilocycles, a low-pass filter with cut-off at 40 kilocycles could be used.

7. *Frequency of oscillators and other vacuum tube circuits in which the harmonic radiation produces an unwanted signal of interference at other than authorized frequencies.* Suppression of this type of interference is specialized and falls in the category of band elimination, in which all frequencies are passed except those desired to be attenuated. The most common method of supression is by the use of a wave trap or absorption

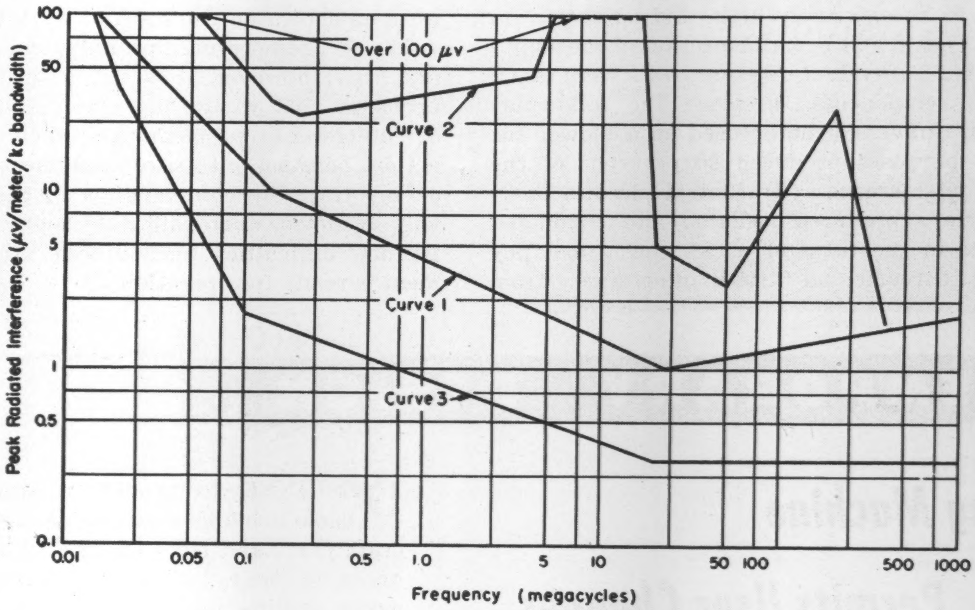


Fig. 6 — Above — Curves of broad-band radiated interference. Curve 1 represents limitations established by MIL-I-16910 (Ships) specifications; Curves 2 and 3, respectively, show interference characteristics of hypothetical equipment before and after application of suppression devices

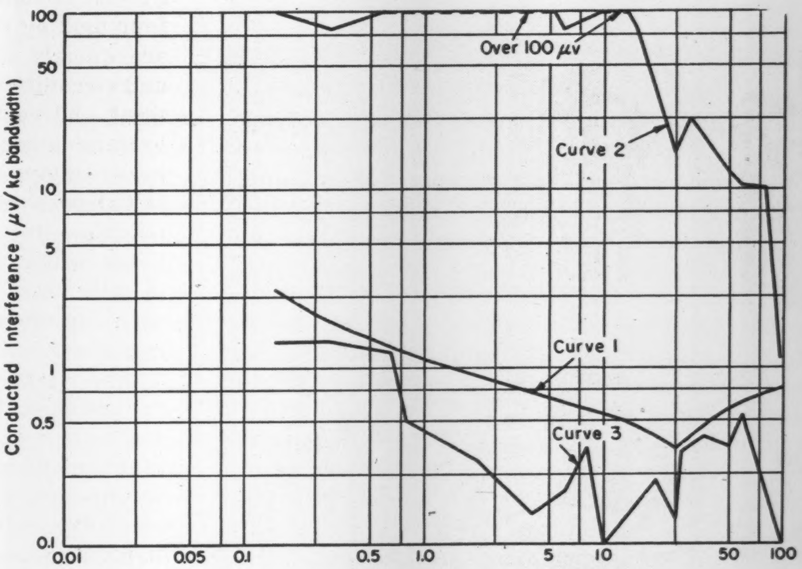


Fig. 7—Right—Curves of broad-band conducted interference, corresponding to those in *Fig. 6*

filter. Shielding is often necessary; the objective is to prevent interaction of electric and/or magnetic fields between the equipment components.

8. *Exposed interconnecting wiring or conductors.* These lines may act as a radiator or conductor for the interference in a manner similar to that for energy radiated from a radio, radar unit or other electric or electronic equipment. This type of interference can be very troublesome. For a solution, it is often necessary to combine component filtering and shielding with separation and individual shielding of conductors.

Application Example: To illustrate how suppression techniques are applied in practice, it will be helpful to assume a hypothetical example in which the equipment was a device manufactured to meet operating requirements with permissible radiated and conducted interference as set forth in MIL-I-16910, Curve 1 of *Figs.* 6 and 7. During final testing, the interference levels were measured and found to be extremely high, and as shown on curve 2 of *Figs.* 6 and 7. An inspection of the equipment, in which individual measurements were taken on various components, disclosed the following: (1) A small universal motor used as a blower for ventilation purposes produced 80 per cent of the conducted interference; (2) control circuits operated by relays produced radiated and conducted interference in the form of clicks each time they closed, but thereafter no further interference from them occurred; and (3) an oscillator tube was giving off harmonic radiation.

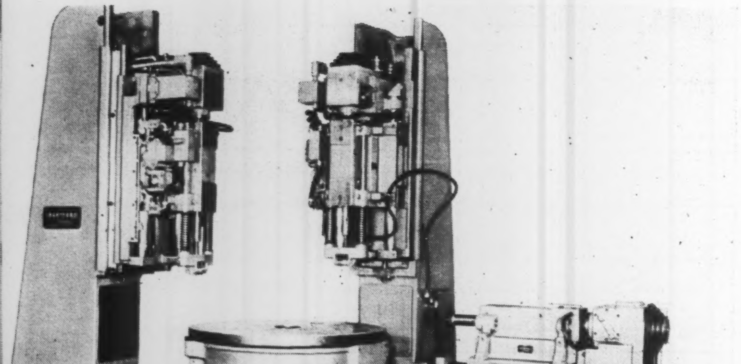
A small filter capable of handling the current, with attenuation over the frequency range of interference, was inserted in the supply line as close as possible to the motor. Capacitors, resonant at interference frequencies from the relays, were installed at the relays. A resonant wave trap was installed in the plate of the oscillator.

All of the above operations were measured progressively and then as a whole. Overall results were satisfactory except for a small amount of radiation interference which was traced to an interconnecting conductor in close proximity to the oscillator circuit. This conductor was picking up interference from the oscillator by induction and was reradiating it as an interference signal. The conductor was replaced by a shielded wire and the interference level from the equipment was then found to be suppressed to a level below the requirements of the specifications. Final measurements were as shown on Curves 3 of *Figs.* 6 and 7.

The foregoing procedure is typical of suppression practices; however, it is not indicative of all the problems that would be encountered. Recognition of interference problems and their mutual interaction between electrical and electronic systems at the time the equipment is in the design stage will, if acted upon, alleviate many of the interference difficulties encountered after the equipment is ready for operation.

CONTEMPORARY DESIGN

Drilling Machine Permits User Changes



DESIGNED to provide a standardized basic machine accurate enough for aircraft parts and rigid enough to hold tolerances in heavy work, a new fully automatic drilling machine made by Hartford Special Machinery Co. accommodates up to four drilling or tapping units, all of which are quickly adjustable radially, vertically and circumferentially. This ease of adjustment and easily changeable cams for programming control allow quick conversion to meet engineering changes and the obsolescence of parts. Weighing 17,800 pounds, the machine has air-hydraulic heads which will drill up to ¾-inch holes in mild steel or ½-inch in stainless steel, with interchangeable index plates for equal or unequal hole patterns. Spindle speeds range from 180 to 6700 rpm, feed ranges from ½-inch to 40 inches per minute. It is adjustable for all factors of standard 96-notch or other index plates or for intermittent or irregular spacing. Special index set-ups available allow up to 192 indexes. Capacity ranges from 87-inch diameter work with 65-inch bolt circle diameter down to 30-inch diameter work with 8-inch diameter bolt circle.

SYSTEMATIC MECHANISM DESIGN—1

New Symbolic Notation + Catalog of Basic Mechanisms = Method for Deducing Practical Mechanisms

By J. Denavit
Dept. of Electrical Eng'g.
and
R. S. Hartenberg
Dept. of Mechanical Eng'g.
Northwestern University
Evanston, Ill.

ADVANTAGES of being able to approach a design problem on a systematic basis are well known. A systematic procedure is fairly direct and allows a study of various combinations of the design parameters to be made and evaluated for the most suitable. In kinematics the lack of such a general approach has been felt keenly. The designer has been forced to study a certain mechanism as a single entity; very often each mechanism is studied as a separate mystery, without orderly reference to other mechanisms. By this method the similarities of apparently unrelated mechanisms are overlooked, since the study is solely involved with a specific mechanism rather than its consideration as part of a whole. The purpose of this article is the study of groups of mechanisms having similar features.

About three-quarters of a century ago, Reuleaux developed some kinematic concepts that appear to be fundamental. They led him toward a symbolic notation for mechanisms that he hoped would make it possible to completely describe, analyze and synthesize mechanisms. This symbolic notation could give some idea of the mechanism to which it was applied, but since it did not include all of the data needed to completely define the geometry of the parts of the mechanism or the whole mechanism, its usefulness was limited.

Reuleaux's concepts concerned the geometry that made the mechanism transform one kind of motion into another. If a mechanism is defined as an ensemble of rigid parts so connected to each other that they will transmit motion, then, said Reuleaux, the important thing about the mechanism is the manner of the connections between parts. (Reuleaux included hydraulic lines as well as belts,

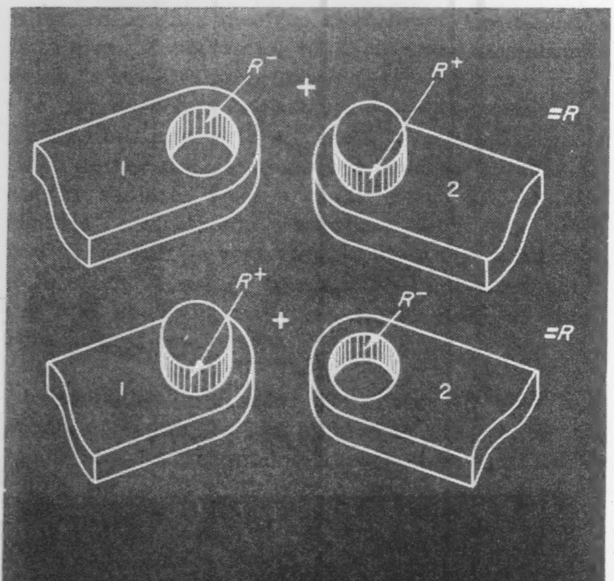


Fig. 1 — Interchangeability of pair elements

ropes and chains. As a first approximation, these "parts" are rigid in one direction.)

The connections between adjacent parts may be made by areas that are in contact, as in a journal bearing, crosshead, screw, or ball-and-socket joint; or the contact may be established by means of lines, as with rollers, gear teeth and cams, or by point contact as in ball bearings. Since each connection always involves a pair of contacts, he spoke of the connections as being made by pairs. With surface or area contact, he called the two surfaces a lower pair, each surface being designated an element of the pair. Line or point contacts he called higher pairs.

In this article the concern will be with plane mechanisms whose parts are connected by lower pairs. It can be seen that this type of mechanism will include pairs permitting only translation and pairs permitting only rotation. Pairs permitting only translation will be called *prisms,* and pairs permitting only rotation will be called *revolutes.* (The words prism and revolute stem from Kennedy's translation of Reuleaux.)

Symbolic Notation. In the symbolic representation of a mechanism, the prism will be designated by the symbol P, and the revolute by the symbol R.

The two elements forming a pair will be distinguished from each other by means of positive and negative signs. This notion is illustrated in *Fig.* 1, where the revolute is used as an example. (In this example, the negative sign has been arbitrarily given to the hollow element.) An interesting property of lower pair elements is their interchangeability, i.e., the fact that it makes no difference on which part the positive or negative element lies, as is also shown in *Fig.* 1.

From the practical standpoint it is not convenient to make revolute connections in the formal manner shown in *Fig.* 1. They are usually made by pin connections as shown in *Fig.* 2. The machine Parts 1 and 2 are connected by the intermediary of the machine Part 3. On this Part 3 lie the two coaxial revolute elements R_1^+ and R_2^+. With this arrangement the motion of Part 1 with respect to Part 2 is obviously the same relative motion that occurs between Parts 1 and 2 of *Fig.* 1.

In some situations two lower pairs can be replaced by a single higher pair as shown in *Fig.* 3. Thus, the two lower pairs R and P of *Fig.* 3*a* permit simultaneous rotation and sliding; the cylinder in the rectilinear guide, *Fig.* 3*b,* allows the same type of motion, even though the construction involves a higher pair by reason of the line contacts.

A plane mechanism is one in which the various parts all move in the same or parallel planes; it will be convenient to speak of a single plane as being the plane in which the motion occurs.

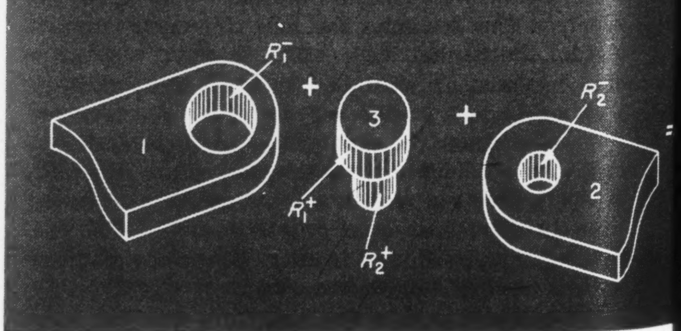
Position of a revolute is defined by the position of its axis of rotation. The position of a prism is completely defined by its direction of translation, which will be represented by a line called the axis of the prism. This prism axis (or line) is not unique except for direction; any line parallel to the direction of translation may be taken as the prism axis. Thus, in *Fig.* 4, the lines 1,2,3 or any parallel thereto, may be taken as the axis. The axes of any revolutes of a plane mechanism will not only have to be parallel to each other, but also perpendicular to the plane of the mechanism. Any prism axis will have to lie in the plane, and thus will be perpendicular to the revolute axes.

In mechanisms a machine part always lies be-

Nomenclature

P = Prism pair
R = Revolute pair
a = Distance between successive z-axes
α = Angle between successive z-axes
θ = Angle between successive x-axes
s = Distance between successive x-axes
f = Number of degrees of freedom

Fig. 2—Pin connection equivalent to a single revolute



tween two others which it connects. The connections are made at each of the two ends of the part; hence for present purposes a machine part is defined as a rigid body carrying a pair element at each extremity. In consequence, while each part is a separate entity, it bears the influence of its two neighbors because of the connecting pairs; and of course it has an influence on its neighbors. At any rate, there is the dependency of one part to the neighboring parts. Because of this, a part must be described in relation to its contacts with the rest of the mechanism, and cannot be considered completely alone.

An example will serve to clarify the foregoing and also show the relations that exist and need defining to give a complete description of a mechanism. The example chosen is the familiar slider-crank, *Fig.* 5; it has four parts and hence four connections.

The four parts are identified in sequence. It makes no difference which part is called No. 1. The frame has been called Part 1, the slider Part 2, the connecting rod Part 3, and the crank Part 4. The connections are by means of four pairs—three revolutes and one prism—each located by means of an axis z. Each pair also has an x-axis, perpendicular to its z-axis, and so located that the distance between successive z-axes is measured along the pertinent x-axis.

The numbering has been taken as counterclockwise. Starting at the left end of Part 1 (the frame), there is the revolute R_4, also common to Part 4. The frame, however, forms a rectilinear guide with its other end, an element of the prism P_1. The z_1-axis is the axis of the prism. Note that the x_1-axis is perpendicular to the revolute axis z_4 of the *preceding* Part 4. Part 2 has a prism element and an element of R_2; the x_2-axis is perpendicular to the *preceding* z_1-axis, and the distance along x_2 locates the revolute axis z_2. Part 3 carries two revolute elements; its x_3-axis is perpendicular to the preceding z_2, and goes from here to locate the z_3-axis. Part 4 also has two revolute elements; its x_4-axis is perpendicular to the preceding z_3, and serves to locate z_4. Next is Part 1 whose x_1-axis is perpendicular to the z_4-axis of the *preceding* part. It is seen that the z-axes which define the direction of the pair axes bear the same identification number as the pair and part. The x-axes bearing the part or pair number get their direction from being perpendicular to the *preceding* z-axis, and the distance between z-axes is measured along the x-axis.

The schematic sketch, *Fig. 6a,* will facilitate discussion of the quantities needed for a symbolic description of the mechanism. The distances between z-axes are designated by the letter a. For this mechanism the distance between z_1 and z_2 is a_1; between z_2 and z_3 it is a_2; between z_3 and z_4 it is a_3; and between z_4 and z_1 it is zero, i.e., $a_4 = 0$. This last is an interesting situation; note that the mechanism as built in *Fig. 6b,* where the rectilinear guide is well away from R_4 but parallel to the position of *Fig. 6a* would have the same motion as the mechanism of *Fig. 6a*. The distance between z_4 and z_1' is then a_4, and the distance between z_1' and z_2 is a_1'; these two distances will always differ by the amount a_1, and it will therefore be convenient to set $a_4 = 0$. This situation is characteristic when the order is from revolute to prism; when going from prism to revolute, as from P_1 to R_2, then a_1 must be accounted for.

The angle between successive z-axes is designated by α. The angle between successive revolute axes is always zero, and the angle between a revolute axis and a prism axis is always 90 degrees. The angle between the z-axes of two prisms may of course assume any value.

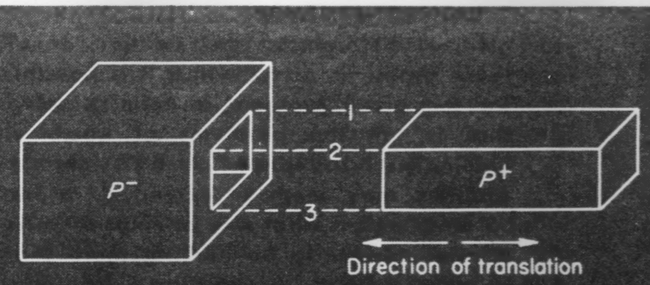


Fig. 4—Above—Prism axis

Fig. 5—Below—Slider-crank mechanism, showing pairs and axes

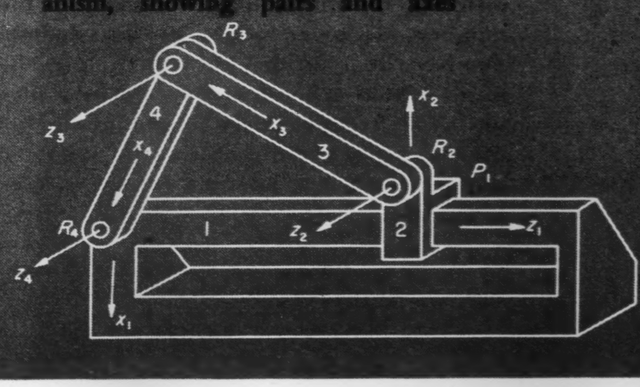
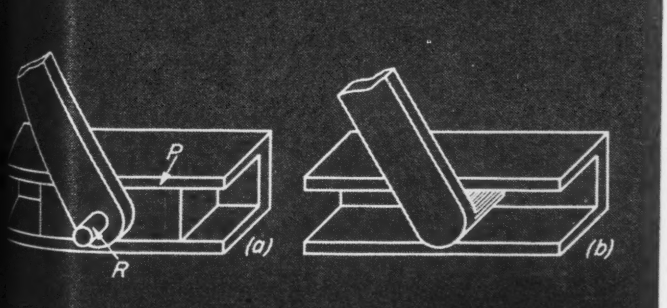


Fig. 3—Equivalence of lower pairs R and P to a single higher pair



REULEAUX'S DEFINITIONS

KINEMATIC SYNTHESIS is the determination of the pairs, chains, or mechanisms necessary to produce a given constrained motion.

DIRECT KINEMATIC SYNTHESIS should give us immediately the mechanisms which are required in each machine to effect a given change of place or form in its work-piece, or to utilize in it a given natural force. It is evident at once, however, that we cannot hope to arrive at useful results by this method. For our analytical investigations have shown us that one and the same motion can be obtained in different and often many different ways. The synthesis must therefore either give us a great number of different simultaneous solutions to the one problem, or must be able to furnish us with that one out of them all which is the best. The latter is, however, impossible, for the practical merits or defects of each single result lie to a considerable extent beyond the sphere of kinematics. Two steam-engines, for instance, in different circumstances may be equally good, equally useful, equally "practical", although they may be kinematically very different. We cannot expect, therefore, to build up any system of general direct analysis which can be useful to us.

INDIRECT KINEMATIC SYNTHESIS should give us beforehand the solution of all those problems under which it is possible for the given problem to fall; to solve, that is, all the problems of machine-kinematics in advance. At first sight this problem may seem so extended, in fact so measureless, that any attempt to solve it may appear to be nothing more than a mere theoretic proposition. We must not forget, however, that some of the investigations we have already made point to the conclusion that the region covered by the problems of machine-kinematics is not unlimited. We may remember, for instance, the remarkable smallness of the number of lower pairs, or the definite number of mechanisms which can be formed from a given chain. So here also we shall find on closer examination that all these kinematic problems lie within a region which it is possible for us at least to survey.

—Adapted from *Kinematics of Machinery* —F. Reuleaux, Translation by A. B. W. Kennedy, Macmillan & Co., London, 1876, Pages 527, 528 and 529.

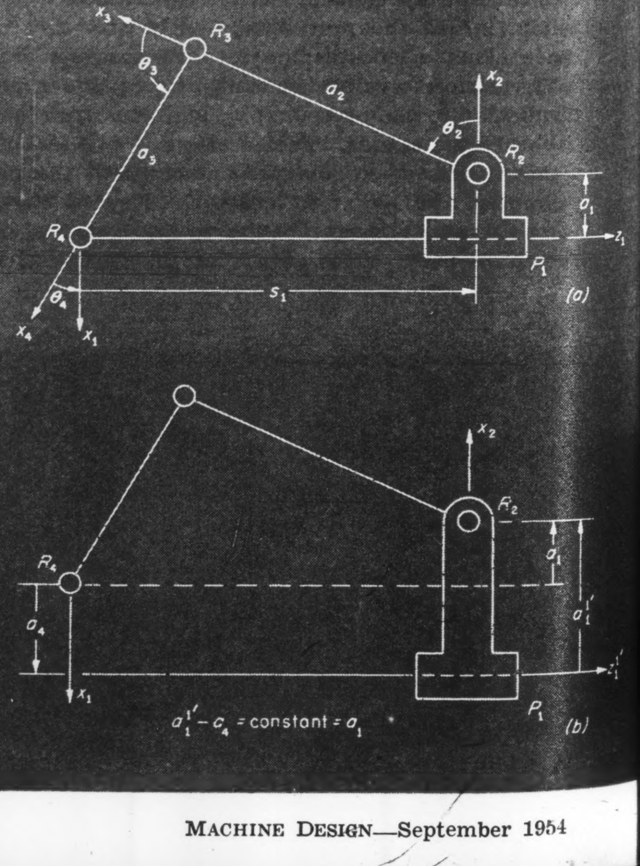
Returning to *Fig.* 6*a*, the angles between the x-axes are designated by θ. For the present mechanism the angle between x_1 and x_2 is $\theta_1 = 180$ degrees, and the other angles are as shown.

The perpendicular distances between x-axes is designated by s. The distance between x_1 and x_2 is s_1. All other distances between successive x-axes are zero in this mechanism, and no more need be said about them.

The parameters a, α, θ and s are sufficient for all plane mechanisms. For the slider-crank only a, θ and s are needed to completely describe it. It must be noted that when the slider-crank moves, the parameters a and α do not change although the parameters θ and s do change. These parameters θ and s describe the relative position between the elements of the R and P pairs. For this reason they are called the pair-variables. In the example of the slider crank s_1 is the pair-variable of P_1, θ_2 is the pair-variable of R_2, θ_3 is the pair-variable of R_3, and θ_4 the pair-variable of R_4. With these data, the symbolic representation of the slider-crank is given by writing the block diagram, *Fig.* 7.

Each box or block represents a machine part; in the box are indicated the pair elements and the parameters defining the machine part itself as well as its relations to the preceding part. Since the chain of boxes so obtained forms a closed loop, it

Fig. 6—(*a*) Schematic of slider-crank showing pair-variables θ and s. (*b*) Parameter a in the sequence R-P



is seen that the description of the chain may be started at any pair element and proceed in either direction.

It is seen that certain of the parameters are zero or 90 degrees, and since this is obviously so, the notation might be simplified by not writing the obvious. This is certainly true for this particular example, but in general all parameters should be shown, for situations more complex than the slider-crank will probably require the use of all parameters. An example of a more complex case is discussed in the second, concluding, article of this series.

This way of writing the symbolic representation of a mechanism (*Fig.* 7) is cumbersome, and it will be more convenient to use a symbolic equation

$$P_1 \left| \begin{array}{c} a_1 \\ 90 \\ 0 \\ s_1 \end{array} \right| R_2 \left| \begin{array}{c} a_2 \\ 0 \\ \theta_2 \\ 0 \end{array} \right| R_3 \left| \begin{array}{c} a_3 \\ 0 \\ \theta_3 \\ 0 \end{array} \right| R_4 \left| \begin{array}{c} 0 \\ 90 \\ \theta_4 \\ 0 \end{array} \right| = 1$$

In this symbolic equation the fact that a positive and negative pair element constitute a pair has been used. Setting the left-hand side equal to unity is convenient since it suggests that the mechanism is closed or continuous.

Actually the equating to unity has a deeper significance than the apparently arbitrary one of convenience. If to the x and z-axes already shown a y-axis is added to form a right-handed system of co-ordinates, each machine part will be equipped with its own system of co-ordinates. Successive linear transformations from one system to the next may be represented by matrices. Since the last transformation will return to the (original) coordinate system from which the first transformation was made, the product of all matrices representing the transformations is unity; this is the real and mathematical justification for the idea. As a matter of fact, the symbolic notation may be extended to include space mechanisms, and here matrix algebra plays a most important part.

Catalog of Synthesized Plane Mechanisms. The term synthesis has become recognized as aptly descriptive of the systematic design of mechanisms. In this article Reuleaux's definitions (see box on Page 170) for (1) *kinematic synthesis,* (2) *direct kinematic synthesis* and (3) *indirect kinematic synthesis* are recognized. Additionally, the practical application of synthesis is described as (4) *design of a complete mechanism* and will be demonstrated in the succeeding article.

A survey as suggested at the conclusion of Reuleaux's description of indirect kinematic synthesis leads to the *Catalog of Synthesized R, P Plane Mechanisms,* Pages 172 to 174. This particular survey is limited to plane lower pair mechanisms. The grouping or classification represented by the *Catalog* provides a framework or arrangement for orderly analysis. The *Catalog* itself is based on the symbolic notation of mathematical character developed in the preceding section. For lower pair plane mechanisms it

1. Provides a complete and unambiguous description of the geometric dimensions controlling the motions of a mechanism and its constituent machine parts, and
2. Establishes in analytic form the relative displacement between either adjacent or remote connected parts.

The classifications presented by the *Catalog* include all possible one, two, three, four and five-pair combinations of revolutes and prisms, certain of which are of particular interest: Those having one degree of freedom, which may be used to transform one motion into another, and those having zero degree of freedom, which may be used to prevent motion. It would be possible to continue the *Catalog* with similar enumeration of mechanisms of more pairs, but the increase in the number of degrees of freedom limits their practical use.

With the aid of this *Catalog* it is possible to deduce the basic components needed to transform one motion into another, provided the mechanism is plane and composed of only lower pairs, as will be demonstrated in the succeeding article.

Criterion of Movability. In the *Catalog,* all possible plane mechanisms that can be formed with one, two, three, four and five lower pairs are enumerated and the most useful functional relations given. It is noted that some of the mechanisms given are not movable, $f = 0$, some are movable with one degree of freedom, $f = 1$, and some have

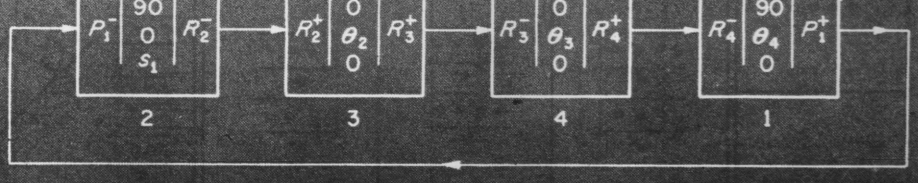
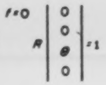
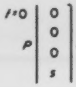
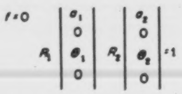
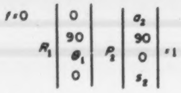
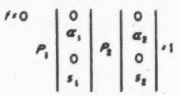
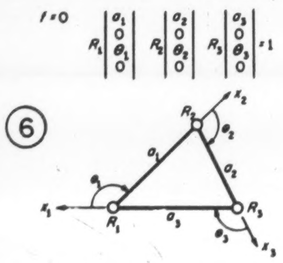
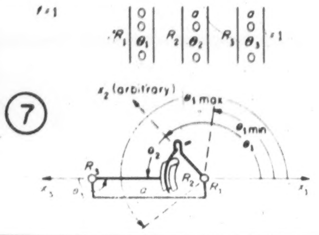
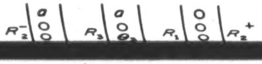
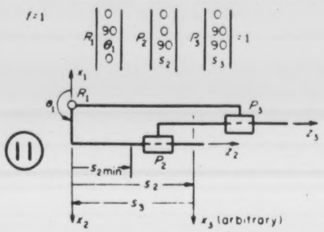
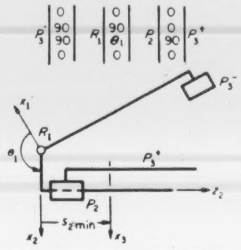
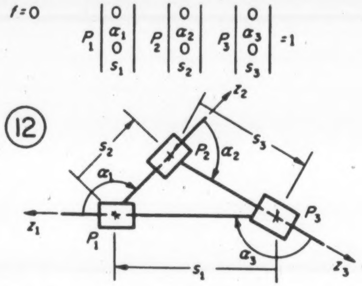
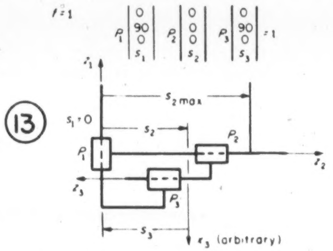
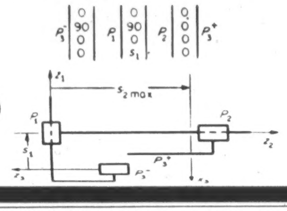
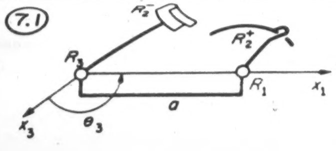


Fig. 7—Block diagram for slider-crank

Catalog of Synthesized R, P Plane Mechanisms

Mechanism	Functional Relations
One Pair	
①  ② 	Trivial and without practical application, but of passing interest since they represent the limiting cases.
Two Pairs	
③ 	Since the mechanism forms a closed loop, $a_1 = a_2 = a$.
④ 	Since the mechanism forms a closed loop, $a_2 = 0$.
⑤ 	Since the mechanism forms a closed loop, $\alpha_1 = \alpha_2 = \alpha$.
Three Pairs	
⑥ 	The functional relations are of the form $$\theta_1 = \cos^{-1}\left[\frac{a_2^2 - a_1^2 - a_3^2}{2a_1a_3}\right]$$ These relations show that the pair-variables reduce to constants unless a_1, a_2 or a_3 are zero; in this case two revolutes become coaxial, leading to the special case below.
⑦ 	If, for the general case, one a is zero, as $a_1 = 0$, whence $a_2 = a_3 = a$ the functional relations become $$\theta_2 = 180° - \theta_1 \;,\; \theta_3 = 180°$$ These relations show that the pairs R_1 and R_2 can move but that the pair R_3 is locked so long as the mechanism forms a closed chain. Since the revolute R_2 is incomplete, it is closed for only a given interval of the pair-variable $\theta_{1\,min} < \theta_1 < \theta_{1\,max}$; when the pair-variable reaches one of the limits, the
⑦.1 	
⑪ 	If, for the general case $a_2 = 0$, whence $a_3 = 0$, the functional relations become $\theta_1 = 180°$ and $s_2 = -s_3$. These relations show that the pairs P_2 and P_3 can move, but that the pair R_1 is locked so long as the mechanism forms a closed chain. Since the prism P_3 is incomplete it is closed for only a given interval of the pair variable $s_2 > s_{2\,min}$; when the pair-variable reaches the limit, the two elements can be separated, whence the pair ceases to exist. The mechanism no longer forms a closed chain and the pair R_1 can be moved as shown. This special case is a locking device, 11.1.
⑪,1 	
⑫ 	The functional relations are $$\frac{s_1}{\sin\alpha_2} = \frac{s_2}{\sin\alpha_3} = \frac{s_3}{\sin\alpha_1}$$ These relations show that if $\alpha_2 = 0$ the pair-variable s_1 becomes zero, and the two other prisms become parallel, leading to the special case.
⑬ 	If, for the general case $a_2 = 0$, then $\alpha_1 = \alpha_3 = 90°$, the functional relations become $s_1 = 0$ and $s_2 = -s_3$. These relations show that the pairs P_2 and P_3 can move, but that the pair P_1 is locked so long as the mechanism forms a closed chain. Since the prism P_3 is incomplete, it is closed for only a given interval of the pair-variable $s_2 < s_{2\,max}$; when the pair-variable reaches the limit, the two elements can be separated, whence the pair ceases to exist. The mechanism no longer forms a closed chain and the pair P_1 can move as shown. This special case constitutes a locking device, 13.1.
⑬.1 	

(7.1)



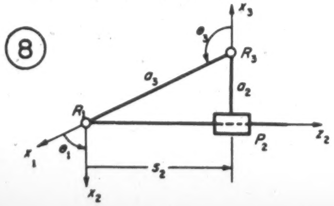
two elements can be separated, whence the pair ceases to exist. The mechanism no longer forms a closed chain and the pair R_3 can be moved as shown.

This special case is seen to constitute a locking device, 7.1.

(8)

$f=0$

$$R_1\begin{vmatrix}0\\90\\\theta_1\\0\end{vmatrix}\quad P_2\begin{vmatrix}a_2\\90\\0\\s_2\end{vmatrix}\quad R_3\begin{vmatrix}a_3\\0\\\theta_3\\0\end{vmatrix}=1$$



The functional relations are

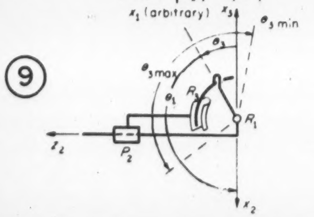
$$\theta_3 = 180° - \theta_1 \ , \ s_2 = a_3 \sin\theta_1 = a_2 \cot\theta_1$$

These relations show that the pair-variables reduce to constants unless a_3 is zero, in which case the revolutes R_1 and R_3 become coaxial, leading to the special case below.

(9)

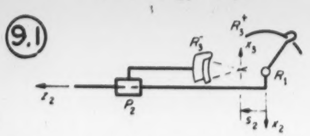
$f=1$

$$R_1\begin{vmatrix}0\\90\\\theta_1\\0\end{vmatrix}\quad P_2\begin{vmatrix}0\\90\\0\\s_2\end{vmatrix}\quad R_3\begin{vmatrix}0\\0\\\theta_3\\0\end{vmatrix}=1$$



(9.1)

$$R_3^+\begin{vmatrix}0\\0\\0\\0\end{vmatrix}\quad R_1\begin{vmatrix}0\\90\\0\\0\end{vmatrix}\quad P_2\begin{vmatrix}0\\90\\0\\s_2\end{vmatrix}R_3^-$$



If for the general case one a is zero, as $a_3 = 0$, whence $a_2 = 0$, the functional relations become

$$\theta_3 = 180° - \theta_1 \ , \ s_2 = 0 \, .$$

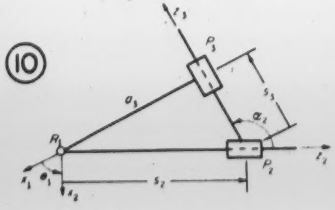
These relations show that the pairs R_1 and R_3 can move but that the pair P_2 is locked so long as the mechanism forms a closed chain. Since the revolute R_3 is incomplete, it is closed for only a given interval of the pair-variable $\theta_{3\,min} < \theta_3 < \theta_{3\,max}$; when the pair-variable reaches one of the limits, the two elements can be separated, whence the pair ceases to exist. The mechanism no longer forms a closed chain and the pair P_2 can be moved as shown.

This special case is seen to constitute a locking device, 9.1.

(10)

$f=0$

$$R_1\begin{vmatrix}0\\90\\\theta_1\\0\end{vmatrix}\quad P_2\begin{vmatrix}0\\\alpha_2\\90\\s_2\end{vmatrix}\quad P_3\begin{vmatrix}a_3\\90\\90\\s_3\end{vmatrix}=1$$



The functional relations are

$$\theta_1 = 180° - \alpha_2$$

$$s_2 = \frac{a_3}{\cos\alpha_2}$$

$$s_3 = a_3 \tan\alpha_2.$$

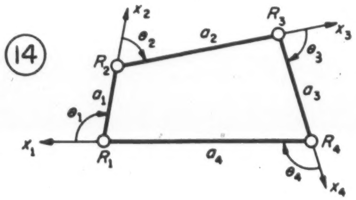
These relations show that the pair-variables reduce to constants unless a_2 and a_3 are zero; in this case the two prisms become parallel, leading to the special case, 11.

Four Pairs

(14)

$f=1$

$$R_1\begin{vmatrix}a_1\\0\\\theta_1\\0\end{vmatrix}\quad R_2\begin{vmatrix}a_2\\0\\\theta_2\\0\end{vmatrix}\quad R_3\begin{vmatrix}a_3\\0\\\theta_3\\0\end{vmatrix}\quad R_4\begin{vmatrix}a_4\\0\\\theta_4\\0\end{vmatrix}=1$$



$$\theta_4 = -\tan^{-1}\frac{a_1\sin\theta_1}{a_4 + a_1\cos\theta_1} + \cos^{-1}\frac{D}{2a_3\sqrt{B}}$$

where

$$D = a_1^2 + a_4^2 - a_2^2 + a_3^2 + 2a_1a_4\cos\theta_1$$

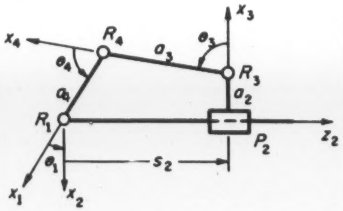
$$B = a_1^2 + a_4^2 + 2a_1a_4\cos\theta_1$$

$$\frac{d\theta_4}{d\theta_1} = -\frac{a_1}{B}\left[a_1 + a_1\cos\theta_1 \pm \frac{a_4\sin\theta_1}{\sqrt{4a_3^2B - D^2}}(2B - D)\right]$$

(15)

$f=1$

$$R_1\begin{vmatrix}0\\90\\\theta_1\\0\end{vmatrix}\quad P_2\begin{vmatrix}a_2\\90\\0\\s_2\end{vmatrix}\quad R_3\begin{vmatrix}a_3\\0\\\theta_3\\0\end{vmatrix}\quad R_4\begin{vmatrix}a_4\\0\\\theta_4\\0\end{vmatrix}=1$$



$$\theta_1 = \cos^{-1}\left[\frac{a_2 + a_3\cos\theta_3}{a_4}\right]$$

$$s_2 = \sqrt{a_3^2 - (a_2 - a_4\cos\theta_1)^2} + a_4\sin\theta_1$$

$$\theta_3 = 180° - (\theta_4 + \theta_1)$$

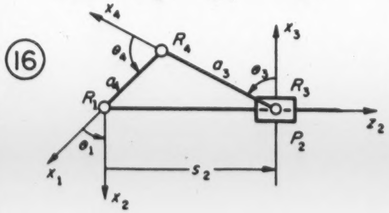
$$\frac{d\theta_4}{d\theta_1} = -\frac{a_4\sin\theta_1}{\sqrt{a_3^2 - (a_2 - a_4\cos\theta_1)^2}} - 1$$

$$\frac{ds_2}{d\theta_1} = -\frac{(a_2 - a_4\cos\theta_1)\,a_4\sin\theta_1}{\sqrt{a_3^2 - (a_2 - a_4\cos\theta_1)^2}} + a_4\cos\theta_1$$

(16)

$f=1$

$$R_1\begin{vmatrix}0\\90\\\theta_1\\0\end{vmatrix}\quad P_2\begin{vmatrix}0\\90\\0\\s_2\end{vmatrix}\quad R_3\begin{vmatrix}a_3\\0\\\theta_3\\0\end{vmatrix}\quad R_4\begin{vmatrix}a_4\\0\\\theta_4\\0\end{vmatrix}=1$$



$$\theta_4 = \cos^{-1}\left[-\frac{a_4\cos\theta_1}{a_3}\right] - \theta_1$$

$$s_2 = \sqrt{a_3^2 - a_4^2\cos^2\theta_1} + a_4\sin\theta_1$$

$$\theta_3 = 180° - (\theta_4 + \theta_1)$$

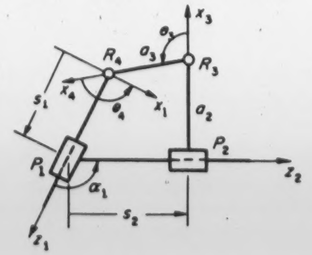
$$\frac{d\theta_4}{d\theta_1} = -\frac{a_4\sin\theta_1}{\sqrt{a_3^2 - a_4^2\cos^2\theta_1}} - 1$$

$$\frac{ds_2}{d\theta_1} = \frac{a_4^2\cos\theta_1\sin\theta_1}{\sqrt{a_3^2 - a_4^2\cos^2\theta_1}} + a_4\cos\theta_1$$

(17)

$f=1$

$$P_1\begin{vmatrix}0\\\alpha_1\\90\\s_1\end{vmatrix}\quad P_2\begin{vmatrix}a_2\\90\\90\\s_2\end{vmatrix}\quad R_3\begin{vmatrix}a_3\\0\\\theta_3\\0\end{vmatrix}\quad R_4\begin{vmatrix}0\\90\\\theta_4\\0\end{vmatrix}=1$$



$$s_1 = -\frac{a_2 + a_3\cos\theta_3}{\sin\alpha_1} \ ; \ \theta_4 = -\alpha_1 - \theta_3$$

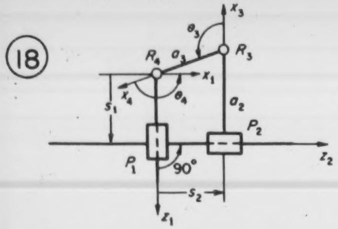
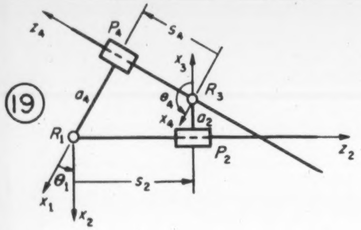
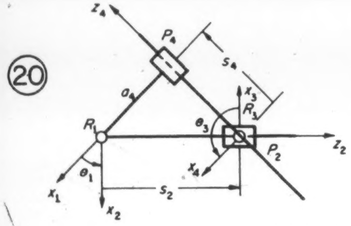
$$s_2 = -\frac{a_2}{\tan\alpha_1} + a_3\left[\frac{\cos\theta_3}{\tan\alpha_1} + \sin\theta_3\right]$$

$$\frac{ds_1}{d\theta_3} = \frac{a_3}{\sin\alpha_1}\sin\theta_3$$

$$\frac{ds_2}{d\theta_3} = a_3\left[\cos\theta_3 - \frac{\sin\theta_3}{\tan\alpha_1}\right]$$

$$\frac{d\theta_4}{d\theta_3} = -1$$

Catalog of Synthesized R, P Plane Mechanisms

Mechanism	Functional Relations
⑱ $f=1 \quad P_1\begin{vmatrix}0\\90\\90\\s_1\end{vmatrix} P_2\begin{vmatrix}a_2\\90\\90\\s_2\end{vmatrix} R_3\begin{vmatrix}a_3\\0\\\theta_3\\0\end{vmatrix} R_4\begin{vmatrix}0\\90\\\theta_4\\0\end{vmatrix}=1$  x_3 θ_3 R_3 R_4 a_3 x_1 x_4 θ_4 s_1 a_2 P_2 P_1 90° z_2 s_2 z_1	$s_1 = -a_2 - a_3\cos\theta_3 \;:\; \theta_1 = -90^\circ - \theta_3$ $s_2 = a_3\sin\theta_3$ $\dfrac{ds_1}{d\theta_3} = a_3\sin\theta_3$ $\dfrac{ds_2}{d\theta_3} = a_3\cos\theta_3 \;:\; \dfrac{d\theta_4}{d\theta_3} = -1$
⑲ $f=1 \quad R_1\begin{vmatrix}0\\90\\\theta_1\\0\end{vmatrix} P_2\begin{vmatrix}a_2\\90\\0\\s_2\end{vmatrix} R_3\begin{vmatrix}0\\90\\\theta_3\\0\end{vmatrix} P_4\begin{vmatrix}a_4\\90\\0\\s_4\end{vmatrix}=1$  z_4 P_4 s_4 x_3 a_4 θ_4 R_3 x_4 a_2 R_1 P_2 z_2 θ_1 s_2 x_1 x_2	$s_4 = \dfrac{a_4}{\tan\theta_1} - \dfrac{a_2}{\sin\theta_1} : \theta_3 = 180^\circ - \theta_1$ $s_2 = \dfrac{a_4}{\sin\theta_1} - \dfrac{a_2}{\tan\theta_1} \;:\; \dfrac{d\theta_3}{d\theta_1} = -1$ $\dfrac{ds_4}{d\theta_1} = \dfrac{1}{\sin^2\theta_1}\left[a_2\cos\theta_1 - a_4\right]$ $\dfrac{ds_2}{d\theta_1} = \dfrac{1}{\sin^2\theta_1}\left[a_2 - a_4\cos\theta_1\right]$
⑳ $f=1 \quad R_1\begin{vmatrix}0\\90\\\theta_1\\0\end{vmatrix} P_2\begin{vmatrix}0\\90\\0\\s_2\end{vmatrix} R_3\begin{vmatrix}0\\90\\\theta_3\\0\end{vmatrix} P_4\begin{vmatrix}a_4\\90\\0\\s_4\end{vmatrix}=1$  z_4 P_4 s_4 x_3 a_4 R_3 θ_3 R_1 z_2 P_2 x_4 θ_1 s_2 x_1 x_2	$s_4 = \dfrac{a_4}{\tan\theta_1} \;:\; \theta_3 = 180^\circ - \theta_1$ $s_2 = \dfrac{a_4}{\sin\theta_1}$ $\dfrac{ds_4}{d\theta_1} = -\dfrac{a_4}{\sin^2\theta_1}$ $\dfrac{ds_2}{d\theta_1} = -\dfrac{a_4\cos\theta_1}{\sin^2\theta_1} \;:\; \dfrac{d\theta_3}{d\theta_1} = -1$
㉑ $f=1 \quad R_1\begin{vmatrix}0\\90\\\theta_1\\0\end{vmatrix} P_2\begin{vmatrix}0\\\alpha_2\\90\\s_2\end{vmatrix} P_3\begin{vmatrix}0\\\alpha_3\\0\\s_3\end{vmatrix} P_4\begin{vmatrix}a_4\\90\\90\\s_4\end{vmatrix}=1$	The functional relations of these mechanisms can be deduced from the functional relations of preceding mechanisms. The number f for these mechanisms can be computed by the method shown in the section *Criterion of Movability.*
㉒ $f=2 \quad P_1\begin{vmatrix}0\\\alpha_1\\0\\s_1\end{vmatrix} P_2\begin{vmatrix}0\\\alpha_2\\0\\s_2\end{vmatrix} P_3\begin{vmatrix}0\\\alpha_3\\0\\s_3\end{vmatrix} P_4\begin{vmatrix}0\\\alpha_4\\0\\s_4\end{vmatrix}=1$	

Mechanism	Functional Relations
Five Pairs	
㉓ $f=2 \quad R_1\begin{vmatrix}a_1\\0\\\theta_1\\0\end{vmatrix} R_2\begin{vmatrix}a_2\\0\\\theta_2\\0\end{vmatrix} R_3\begin{vmatrix}a_3\\0\\\theta_3\\0\end{vmatrix} R_4\begin{vmatrix}a_4\\0\\\theta_4\\0\end{vmatrix} R_5\begin{vmatrix}a_5\\0\\\theta_5\\0\end{vmatrix}=1$	The mechanisms with $f > 1$ are listed for completeness; they have no direct application to the transformation of movement, since to one input movement no unique output movement exists.
㉔ $f=2 \quad R_1\begin{vmatrix}a_1\\0\\\theta_1\\0\end{vmatrix} R_2\begin{vmatrix}a_2\\0\\\theta_2\\0\end{vmatrix} R_3\begin{vmatrix}a_3\\0\\\theta_3\\0\end{vmatrix} R_4\begin{vmatrix}0\\90\\\theta_4\\0\end{vmatrix} P_5\begin{vmatrix}a_5\\90\\0\\s_5\end{vmatrix}=1$	
㉕ $f=2 \quad R_1\begin{vmatrix}a_1\\0\\\theta_1\\0\end{vmatrix} R_2\begin{vmatrix}a_2\\0\\\theta_2\\0\end{vmatrix} R_3\begin{vmatrix}0\\90\\\theta_3\\0\end{vmatrix} P_4\begin{vmatrix}0\\\alpha_4\\90\\s_4\end{vmatrix} P_5\begin{vmatrix}a_5\\90\\90\\s_5\end{vmatrix}=1$	
㉖ $f=2 \quad R_1\begin{vmatrix}a_1\\0\\\theta_1\\0\end{vmatrix} R_2\begin{vmatrix}0\\90\\\theta_2\\0\end{vmatrix} P_3\begin{vmatrix}0\\\alpha_3\\90\\s_3\end{vmatrix} P_4\begin{vmatrix}0\\\alpha_4\\0\\s_4\end{vmatrix} P_5\begin{vmatrix}a_5\\90\\90\\s_5\end{vmatrix}=1$	
㉗ $f=2 \quad R_1\begin{vmatrix}0\\\alpha_1\\90\\s_1\end{vmatrix} P_2\begin{vmatrix}a_2\\90\\90\\s_2\end{vmatrix} R_3\begin{vmatrix}0\\90\\\theta_3\\0\end{vmatrix} P_4\begin{vmatrix}a_4\\90\\0\\s_4\end{vmatrix} R_5\begin{vmatrix}0\\90\\\theta_5\\0\end{vmatrix}=1$	
㉘ $f=2 \quad P_1\begin{vmatrix}0\\\alpha_1\\90\\s_1\end{vmatrix} P_2\begin{vmatrix}0\\\alpha_2\\0\\s_2\end{vmatrix} P_3\begin{vmatrix}a_3\\90\\90\\s_3\end{vmatrix} R_4\begin{vmatrix}a_4\\0\\\theta_4\\0\end{vmatrix} R_5\begin{vmatrix}0\\90\\\theta_5\\0\end{vmatrix}=1$	The functional relations of these mechanisms can be deduced from the functional relations of preceding mechanisms. The number f for these mechanisms can be computed by the method shown in the section *Criterion of Movability.*
㉙ $f=2 \quad P_1\begin{vmatrix}0\\\alpha_1\\90\\s_1\end{vmatrix} P_2\begin{vmatrix}0\\\alpha_2\\0\\s_2\end{vmatrix} P_3\begin{vmatrix}0\\\alpha_3\\0\\s_3\end{vmatrix} P_4\begin{vmatrix}a_4\\90\\90\\s_4\end{vmatrix} R_5\begin{vmatrix}0\\90\\\theta_5\\0\end{vmatrix}=1$	
㉚ $f=3 \quad P_1\begin{vmatrix}0\\\alpha_1\\0\\s_1\end{vmatrix} P_2\begin{vmatrix}0\\\alpha_2\\0\\s_2\end{vmatrix} P_3\begin{vmatrix}0\\\alpha_3\\0\\s_3\end{vmatrix} P_4\begin{vmatrix}0\\\alpha_4\\0\\s_4\end{vmatrix} P_5\begin{vmatrix}0\\\alpha_5\\0\\s_5\end{vmatrix}=1$	

more than one degree of freedom. The purpose of this section is to indicate a method for deducing the number of degrees of freedom of a closed mechanism by considering only the symbolic equation which describes it. These definitions are needed:

1. The *number of degrees of freedom* of a mechanism is the number of its pair-variables that can be arbitrarily fixed at the same time.
2. A *pair is locked* when no relative motion between elements is possible; its pair-variable has a constant value completely defined by the parameters of the mechanism (a and α values).
3. A *pair is movable* when relative motion between elements is possible.

Consider the following identities:

$$R_1\left|\begin{matrix}0\\0\\\theta_1\\0\end{matrix}\right| R_2 \equiv R'$$

$$P_1\left|\begin{matrix}0\\0\\0\\s_1\end{matrix}\right| P_2 \equiv P'$$

$$P_1\left|\begin{matrix}0\\\alpha_1\\\theta_1\\s_1\end{matrix}\right| P_2\left|\begin{matrix}0\\\alpha_2\\0\\s_2\end{matrix}\right| P_3 \equiv P_1'\left|\begin{matrix}0\\\alpha_1+\alpha_2\\\theta_1'\\s_2'\end{matrix}\right| P_2'$$

(θ_1 has to equal 90° or 0°)

The meaning of each identity is that when the left-hand side appears in a mechanism, it may be replaced by the right-hand side without changing the relations among the pair-variables of all other pairs of the mechanism. The equation found after all such simplifications have been effected will be called the *reduced form of the symbolic equation.*

From a consideration of the identities and the *Catalog,* a method can be devised which will make possible the determination of the movability of each pair of a mechanism. The procedure is:

1. Reduce the symbolic equation by searching for all the possible combinations of pairs to which one of the three identities could be applied. Each application of an identity will lead to one degree of freedom.
2. Match the reduced equation with one of the *Catalog* equations, and thus establish the number of degrees of freedom left in the reduced equation.
3. The total number of degrees of freedom is the sum of the numbers found in 1 and 2.

EXAMPLE: Consider the symbolic equation

$$R_1\left|\begin{matrix}0\\0\\\theta_1\\0\end{matrix}\right| R_2\left|\begin{matrix}0\\90\\\theta_2\\0\end{matrix}\right| P_3\left|\begin{matrix}0\\\alpha_3\\90\\s_3\end{matrix}\right| P_4\left|\begin{matrix}0\\\alpha_4\\0\\s_4\end{matrix}\right| P_5\left|\begin{matrix}a_5\\90\\90\\s_5\end{matrix}\right| R_6\left|\begin{matrix}a_6\\0\\\theta_6\\0\end{matrix}\right| = 1$$

By application of *two* identities, the reduced equation is found to be

$$R_1'\left|\begin{matrix}0\\90\\\theta_1'\\0\end{matrix}\right| P_2'\left|\begin{matrix}0\\\alpha_3+\alpha_4\\90\\s_2'\end{matrix}\right| P_3'\left|\begin{matrix}a_3'\\90\\90\\s_3'\end{matrix}\right| R_6\left|\begin{matrix}a_6\\0\\\theta_6\\0\end{matrix}\right| = 1$$

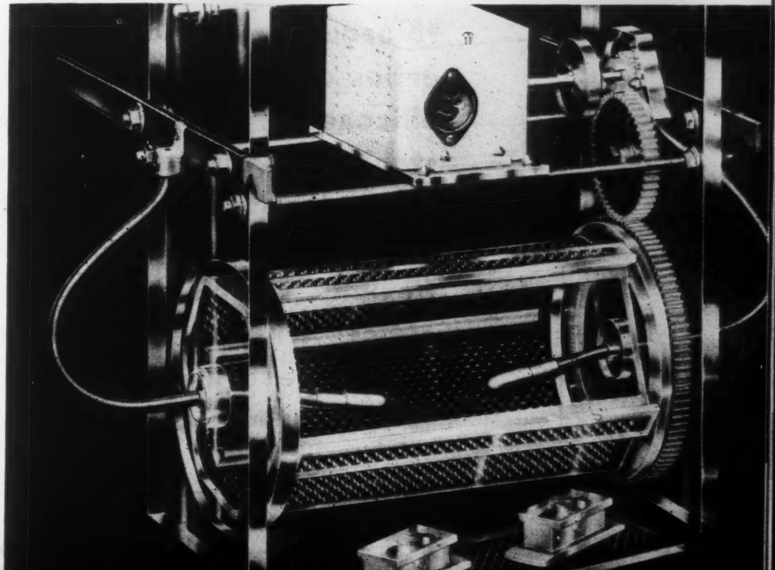
This is equivalent to (circular permutation)

$$P_2'\left|\begin{matrix}0\\\alpha_3+\alpha_4\\90\\s_2'\end{matrix}\right| P_3'\left|\begin{matrix}a_3'\\90\\90\\s_3'\end{matrix}\right| R_6\left|\begin{matrix}a_6\\0\\\theta_6\\0\end{matrix}\right| R_1'\left|\begin{matrix}0\\90\\\theta_1'\\0\end{matrix}\right| = 1$$

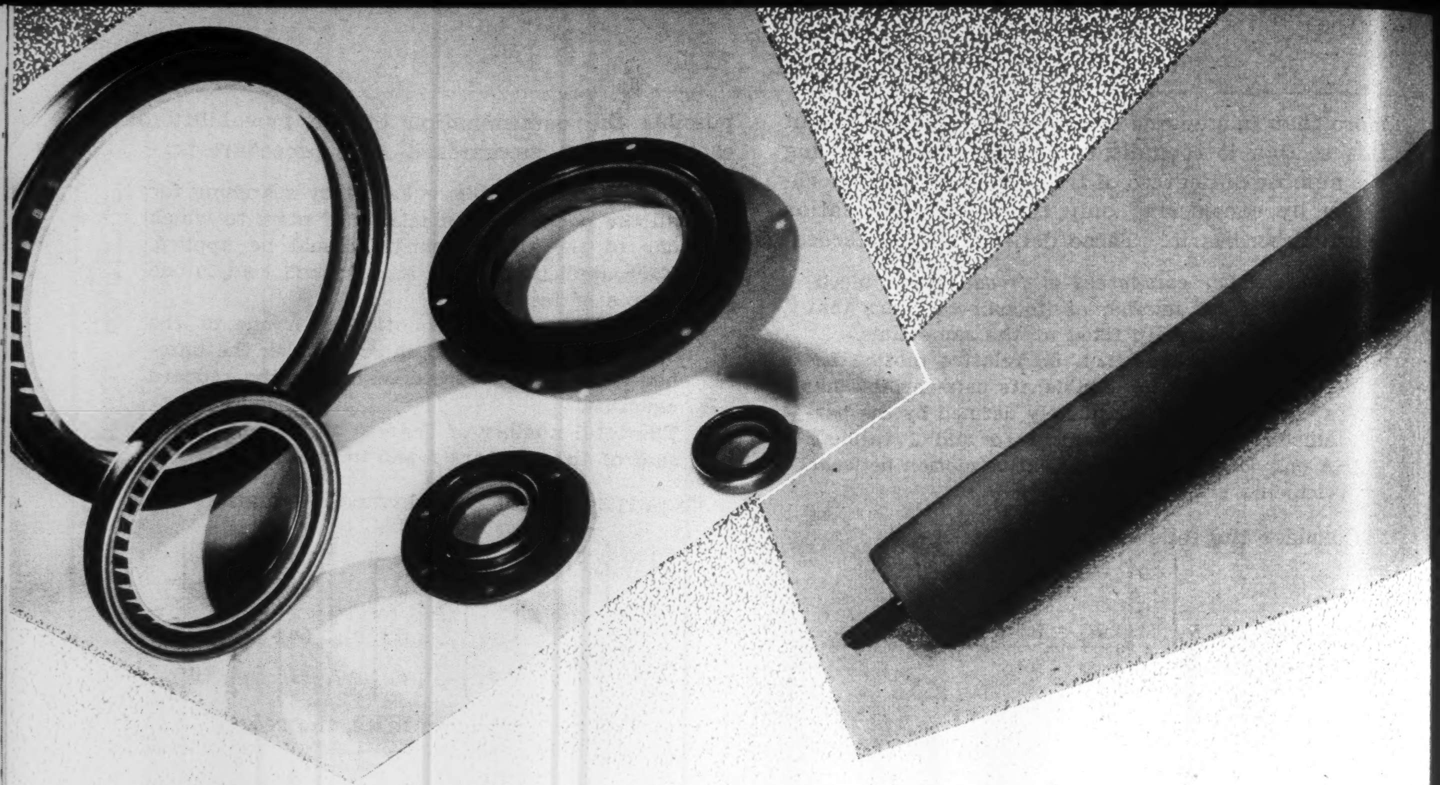
which is found in the *Catalog* and has *one* degree of freedom. The total number of degrees of freedom of the mechanism described by the equation given is therefore *three.*

CONTEMPORARY DESIGN

Acrylic Plastic Plating Barrel



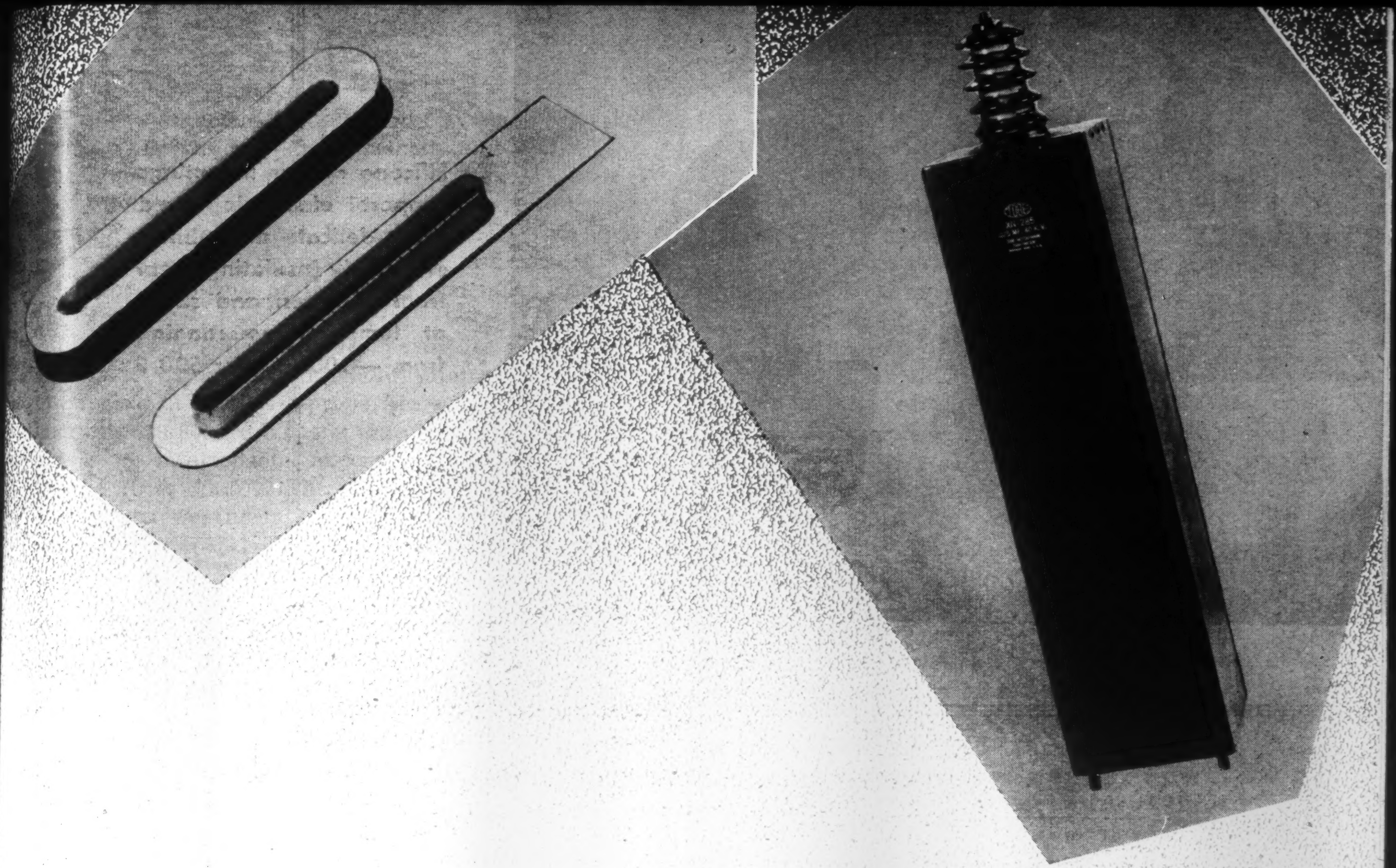
FABRICATED of acrylic plastic this portable plating barrel designed for small quantities weighs only 27 pounds. Driven by a torque-rated geared motor, the barrel uses standard electric supply. Inside dimensions are 6 by 12 inches with 3/32-inch perforations. Gears and sides are ⅝-inch thick and will withstand 180 F temperatures. All metal parts exposed to plating solution are made of Monel. The barrel is made by Starline Products.



New Developments in SILICONES

By T. A. Kauppi
Manager, Product Engineering
Dow Corning Corp.
Midland, Mich.

Silicones are a relatively new and unusual class of engineering materials. Although physical forms of silicones—fluids, rubbers, plastic resins, greases—are similar to organic materials, their properties are often quite different. Silicones are noted for thermal stability, excellent dielectric characteristics, water repellency, and oxidation resistance—a flexible combination of properties which suggest many novel design possibilities



JUST as the molecular structures of silicones are unique, so are their properties. Silicones are built around "skeletons" of silicon and oxygen atoms, which give the materials their unusual properties. Attached to these skeleton chains are various organic groups which modify the basic molecular structures. The resulting semiinorganic materials can thus be produced in a number of physical forms with differing characteristics.

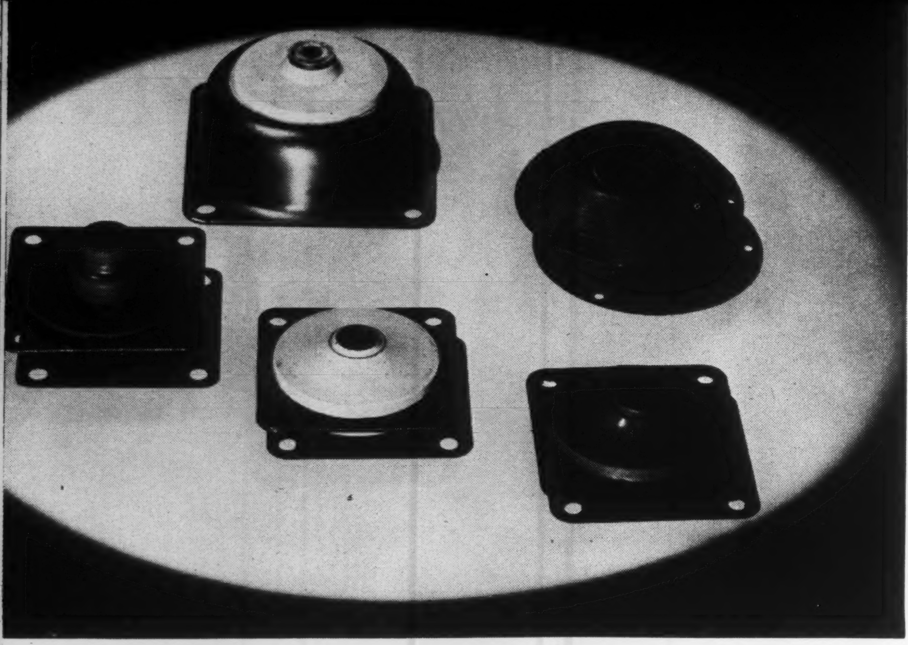
In general, silicones are water repellent and have good dielectric properties. They are highly resistant to oxidation, weathering, and ozone. They are inert to metals, plastics, and rubber, and are resistant to a variety of chemicals. Possessing properties which make them durably serviceable in many cases where other materials fail, silicones have made possible design changes heretofore impractical.

Of particular interest are some of the newer developments in silicones. These new forms, plus some of the more standard varieties of silicones, are discussed in this article.

RUBBER

Silicone rubber is a synthetic, elastomeric material which retains its rubbery properties at temperatures as low as −100 F and yet renders excellent service at temperatures as high as 500 F.

This relatively new semi-inorganic rubber is in a class by itself among rubbery materials. It contains no organic rubber, and its unique properties are obtained by the proper compounding of stable silicone polymers with heat-stable fillers. Silicone rubber makes possible the design and production of equipment suitable for operation at temperatures above and below the limits set by



Silicone rubber mountings support electronic and other delicate assemblies, effectively insulating them from vibration and shock at temperatures ranging from —100 to over 500 F

Table 1—Properties of Silicone Rubbers

Property	Silastic* 50	80	122	152	240	250
Color after curing	White	White	Gray	Red	Translucent	Orange-tan
Specific gravity	1.25	1.25	1.5	1.2	1.2	1.2
Hardness (Shore A)	52	80	90	50	42	48
Hours cured at 482 F	24	24	4	24	24	24
Tensile strength (psi, ave.)	900	800	630	800	600	625
Elongation (%, ave.)	300	200	40	330	265	330
Brittle point (F)	—80	—80	—70	—80	—130	—130
Compression set (% at 302 F)	35	30	85	60	56	50
Dielectric strength (v/mil)	571	579	450	350	400	400
Dielectric constant,						
at 10^2 cycles	3.11	2.95	3.6	2.9	3.1	3.4
at 10^6 cycles	3.07	2.92	3.2	2.9	3.0	3.2
Power factor,						
at 10^2 cycles	0.0036	0.00096	0.020	0.0015	0.003	0.004
at 10^6 cycles	0.00204	0.0028	0.006	0.001	0.004	0.010

* Dow-Corning silicone rubbers.

Table 2—Effect of Continuous Heat Aging

Aging Temperature and Time	Flex Life* Silastic 50	Flex Life* Silastic 80	Flex Life* Organic Rubber	Durometer Silastic 50	Durometer Silastic 80	Durometer Organic Rubber	Tensile Strength (psi) Silastic 50	Tensile Strength (psi) Silastic 80	Tensile Strength (psi) Organic Rubber	Elongation (per cent) Silastic 50	Elongation (per cent) Silastic 80	Elongation (per cent) Organic Rubber
Initial	OK	OK	OK	54	80	61	931	800	2077	310	260	530
300 F												
3 days	OK	OK	OK	56	80	78	904	816	1018	276	244	69
7 days	OK	OK	§	59	81	§	885	744	§	257	216	§
8 weeks	OK	OK		64	88		792	616		173	125	
30 weeks	OK	OK		64	89		437	527		71	44	
39 weeks	OK	†		65	†		410	†		65	†	
392 F												
16 hours	OK	OK	OK	..	..	85	...	...	332	...	...	5
1 week	OK	OK	‡	55	81	‡	884	696	‡	257	157	‡
16 weeks	OK	OK		63	94		568	640		118	54	
24 weeks	OK	†		64	†		558	†		115	†	
28 weeks	OK			66			540			96		
480 F												
4 hours	OK	OK	OK	..	..	98	...	...	3550	...	...	11
1 day	OK	OK	**	59	80	**	856	727	**	235	187	**
4 weeks	OK	OK		63	89		688	560		96	15	
6 weeks	OK	†		68	†		632	†		87	†	

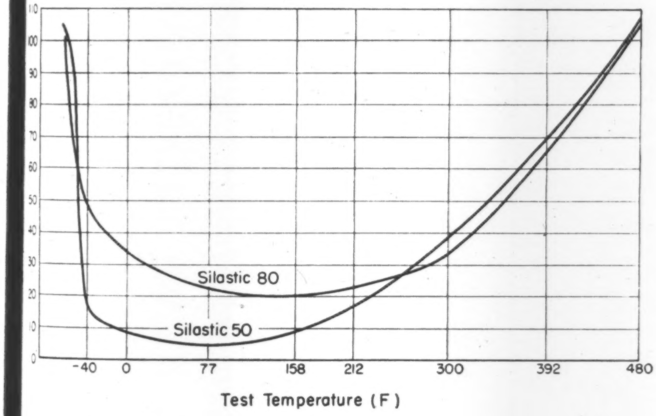
*Test—180 degree bend over ⅜-inch mandrel without breaking. †Failure point, flexural test. §Failed after 4 days at 300 F. ‡Failed flex test after 19 hours at 392 F. **Failed flex test after 8 hours at 480 F.

conventional organic materials.

Typical silicone-rubber components include molded mechanical parts, gaskets and seals, O-rings, rollers, and sponge parts. Silicone-rubber rod, tubing, and electrical lead wire and cable insulation are fabricated by extrusion. And silicone-rubber-coated fabrics, ducting and hose are made for a variety of industrial and military applications.

In general, silicone-rubber parts are inert, resistant to oxidation, and show minimum change in physical or dielectric properties after continuous long-term exposure to temperatures from −60 to 350 F or intermittent exposure to temperatures from −70 to 500 F. They also show excellent resistance to weathering, and to a variety of hot oils and chemicals.

Fig. 1—Compression set for two relatively new silicone rubbers (samples were cured for 24 hours at 480 F; tested for 22 hours at temperature)



These characteristics properties can be further enchanced by compounding for optimum service under particular operating conditions. Silicone-rubber stocks designed for extreme-temperature applications, for example, have brittle points lower than −130 F, are flexible at temperatures below −100 F, and remain serviceable at temperatures up to 500 F. The fact that the low compression-set silicone-rubber stocks are usually tested for resistance to permanent compression set at 150 C, whereas organic rubbers are tested at 70 C, is a measure of their advantage in service at elevated temperature.

Stocks compounded for dielectric applications are unique because of their high thermal conductivity, low moisture absorption, excellent resistance to corona, and good physical and dielectric properties. These characteristics remain relatively constant over a wide range of temperatures and frequencies.

Other silicone rubbers that have particular applications are cloth coating pastes that cure to a tough, resilient, heat-stable coating with "adhesive" characteristics; and stocks completely free of any potentially toxic ingredients or additives for handling pharmaceuticals, medicinals or recirculating blood.

Among three recent silicone rubber developments are two general-purpose stocks, which can be blended to yield any durometer hardness between 50 and 80, and an extreme-temperature, low-compression-set, low-shrink silicone rubber which can be used in food or cosmetic processing.

These two new general purpose stocks (Silastic

Cut from a piece of silicone-rubber-coated glass cloth, this pneumatic valve diaphragm is still in excellent condition after more than 6½ years of service in ambient temperatures ranging up to 140 F. Previously used diaphragm materials regularly failed in less than a year

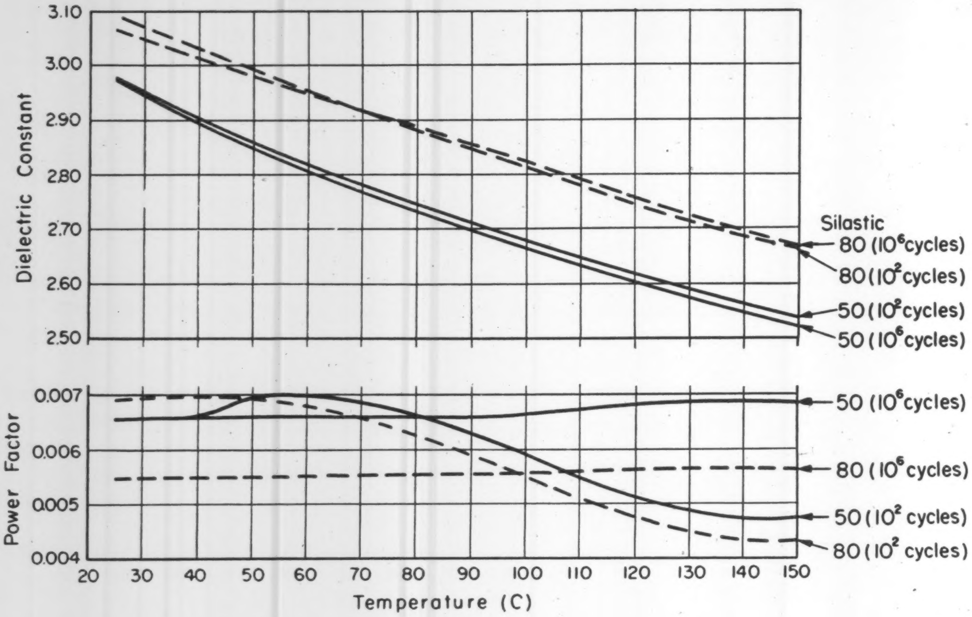
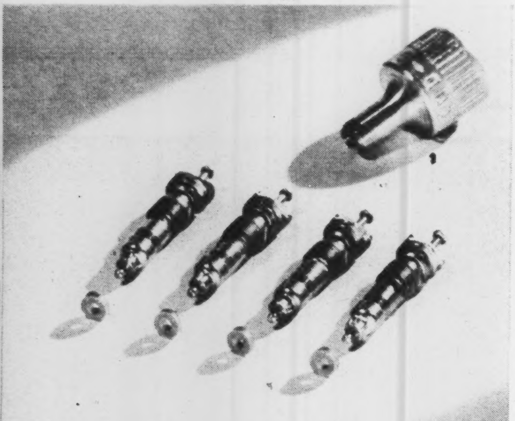


Fig. 2 — Dielectric properties of two silicone rubbers

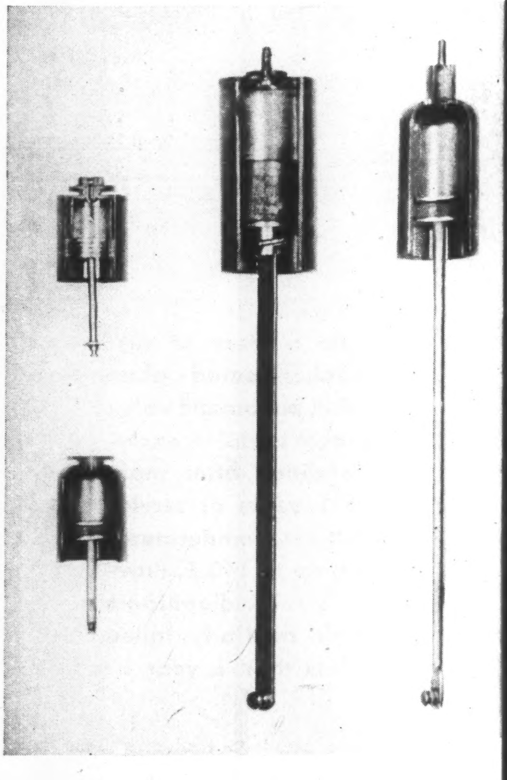
50 and Silastic 80) are high-strength materials having good resistance to compression set, low water absorption and excellent dielectric properties. Blendable with each other, they also offer the advantage that they can be easily pigmented to obtain a wide range of colors and shades. They are readily adaptable to molding, extruding, laminating, calendering or wire covering.

Typical properties of silicone rubbers, including these two stocks, are shown in *Table* 1. Effect of exposure to extreme temperatures is shown generally by *Table* 2. With consideration of the fact that the results are typical of the effect of continuous exposure, *Table* 2 gives an approximate measure of the service life that might be expected. Influence of temperature on compression set is



Miniature washer-shaped, silicone-rubber gaskets are stamped into bus and truck tire valve cores during manufacture

Silicone-rubber washers have replaced machined brass or graphite pistons in the damping mechanism of an automatic popup toaster. For every 1000 toasters, 199 pounds of brass are replaced by only 86 pounds of steel. Cylinders do not have to be macined to close tolerances but can even be out of round. Operating temperatures are about 350 F



shown in *Fig.* 1; and on dielectric properties in *Fig.* 2.

Another recently introduced silicone-rubber stock (Silastic 675) offers an unusual combination of desirable properties. It is serviceable from −100 to 500 F, has excellent resistance to compression set, is a good dielectric, and exhibits unusually low shrinkage in molding and in service at elevated temperatures.

This rubber has a brittle point lower than −130 F. Compression set is in the range of 15-20 per cent after 22 hours at 300 F; 20-28 per cent after 70 hours. It retains excellent dielectric properties over a wide range of temperatures and frequencies. Well suited for applications where low shrink in service is required, the new stock shows less than 2.5 per cent shrink after 1000 hours at 390 F, less than 7 per cent after 1000 hours at 480 F in tests. And, because Silastic 675 does not contain any toxic additives, it can be safely used in applications where cosmetics, foods or pharmaceuticals may be in contact with the fabricated part.

FOAMS

Several new silicone resins fill a long felt need for lightweight, nonflammable structures that will retain compressive strength at high temperatures and can be foamed in place. Two recently developed expansible resins can be foamed in place to form uniform, closed-cell structures weighing only 8 to 24 pounds per cubic foot.

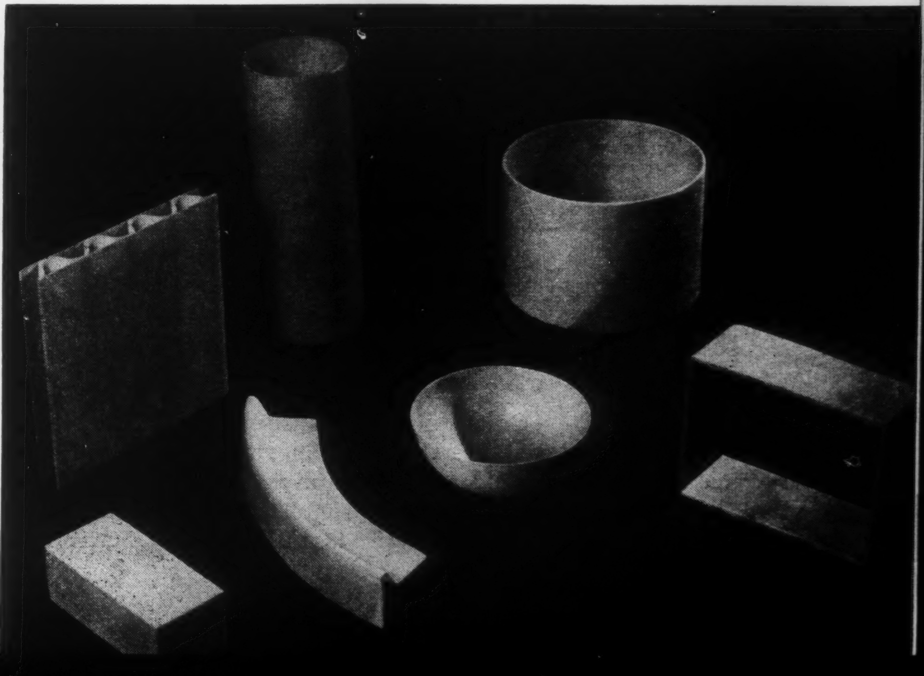
Such foams have been exposed to temperatures as high as 700 F or more for over 20 hours with very little structural or dimensional change. Sections only half an inch in thickness can be brought to a red heat over an open flame without showing significant decomposition. Only a slight warmth can be felt on the opposite face.

These properties suggest the use of "sandwich" constructions, foamed-in-place reinforcements, or parts machined from blocks of silicone foam in such applications as fire-walls, electrical and acoustical insulating bodies, and heat-stable bouyant structures.

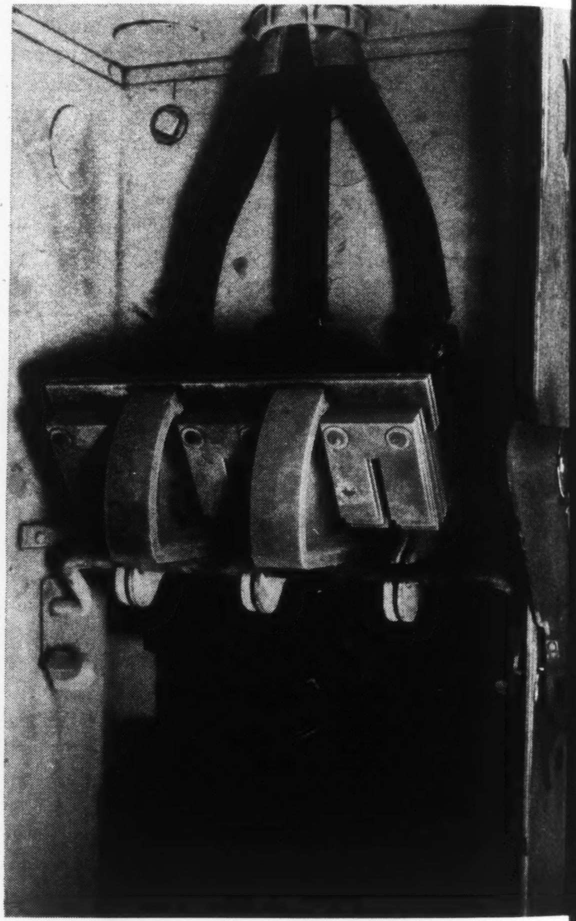
LAMINATES

Silicone resins are available for either high or low-pressure laminating of electrical or structural parts. Properties of typical plastic laminates made with these resins are shown in *Table* 3.

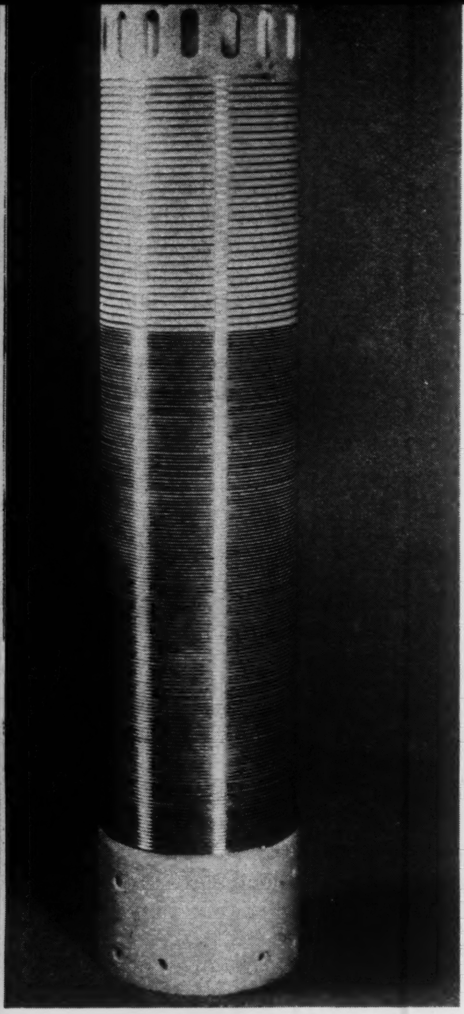
Rigid Class H electrical-insulating components are usually made of either continuous-filament or staple-fiber glass cloth bonded with silicone resin. Silicone-glass laminates are characterized by excellent dielectric properties over a wide frequency range, low water absorption, excellent arc resist-



Low-pressure silicone-glass laminates can easily be made in a variety of shapes and sizes. These samples include a mandrel-wrapped tube, 90-degree angle sections, molded hemispheric and rim section parts, a sandwich assembly, and a flat section 1¼ inches thick



Parts machined of silicone-glass laminates function efficiently after several years of service in high-voltage switch boxes where ambient heat often chars and weakens conventional laminated insulator links



Loss factor of this silicone-glass tube is low enough to permit winding a radio-frequency coil directly on the tube. The tube is easily machined, withstands continuous operation at temperatures up to 200 C, and meets military shock requirements

Photo, courtesy Federal Telecommunications Laboratories Inc.

Table 3—Typical Properties of Silicone-Glass Laminates*

Property	2103 112 Cloth	2104 181 Cloth	2105 112 Cloth	2106 181 Cloth
Flexural strength, 77 F (1000 psi)	27–32	37.3	37	50
Water absorption after 24-hr immersion (%)	1.0–1.3	0.20	0.05	0.09
Dielectric strength, ⅛-in. section (v/mil)				
as received	300	200–250	300	100
after 200 hr at 500 F	80–100	51	364	.....
Power factor, 10^5 cycles				
Condition A†	0.0022	0.0014	0.0019	0.0033
Condition D, 23/24§	0.0089	0.0060	0.0044	0.030
Arc resistance (sec)	350	275	260	240
Dielectric constant, 10^5 cycles				
Condition A†	4.13	3.70	3.31	3.90
Condition D, 23/24§	4.50	4.50	3.31	4.30

*⅛-inch thick. †As received. §After 24 hours immersion in distilled water at 23 C.

ance and a high order of heat stability.

A recently developed silicone resin for bonding laminates to be used as structural parts provides initial strength and stiffness values approaching those of the organics. Typical ⅛-inch samples show flexural strengths in the range of 50,000 psi at room temperature even before curing. Even more important, this high physical strength is retained after prolonged exposure to elevated temperatures.

Tests indicate that in high-temperature service all of the silicone-glass laminates retain this high strength. After 200 hours at 500 F, for example, the tensile strength of magnesium drops to 6000 psi while that of aluminum is 5000 to 9000 psi. Silicone-glass laminates, however, average over 20,000 psi after the same exposure.

■ DIELECTRICS ■ ■ ■

Regardless of the original electrical properties of an insulating material, thermal aging inevitably weakens the material physically until eventually vibration or moisture severely impair electrical properties. Service life of a dielectric is, therefore, a function of its resistance to thermal aging. The silicones combine excellent dielectric properties with an exceptional degree of thermal stability. For this reason silicone dielectrics give longer service life than organic dielectrics.

Compounds: First of the silicone dielectrics to become commercially available was a smooth, translucent compound which retained the consistency of petroleum jelly even after prolonged exposure to temperatures ranging from −70 to 400 F. Highly resistant to oxidation, this compound is also more water repellent than paraffin or wax.

Over a wide frequency range the dielectric constant of the compound falls about midway between that of quartz and organic transformer oil, *Fig.* 3. Power factor is less than 0.003 at frequencies up to 10 megacycles, and a volume resistivity of more than 10^{12} ohm-cm is retained at temperatures up to 400 F, as indicated by *Fig.* 4. Because a thin film of the compound prevents moisture from forming a continuous conducting film on insulating surfaces, surface resistivity remains high and surface leakage is eliminated. This compound first became popular with the aircraft industry as a high-temperature ignition seal. It is now widely used as a water-repellent dielectric coating or seal for power-transmission and oil-well-survey equipment exposed to weathering or high temperature.

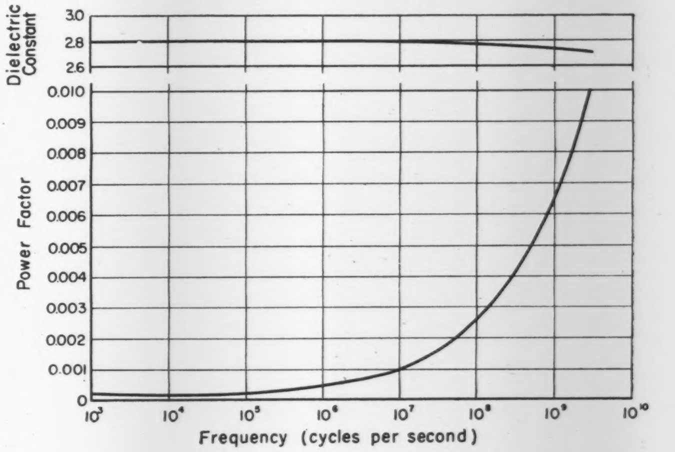
Fluids: Low loss factors at elevated temperatures, inertness to moisture, oxidation resistance and heat stability make silicone fluids unusual among liquid dielectrics.

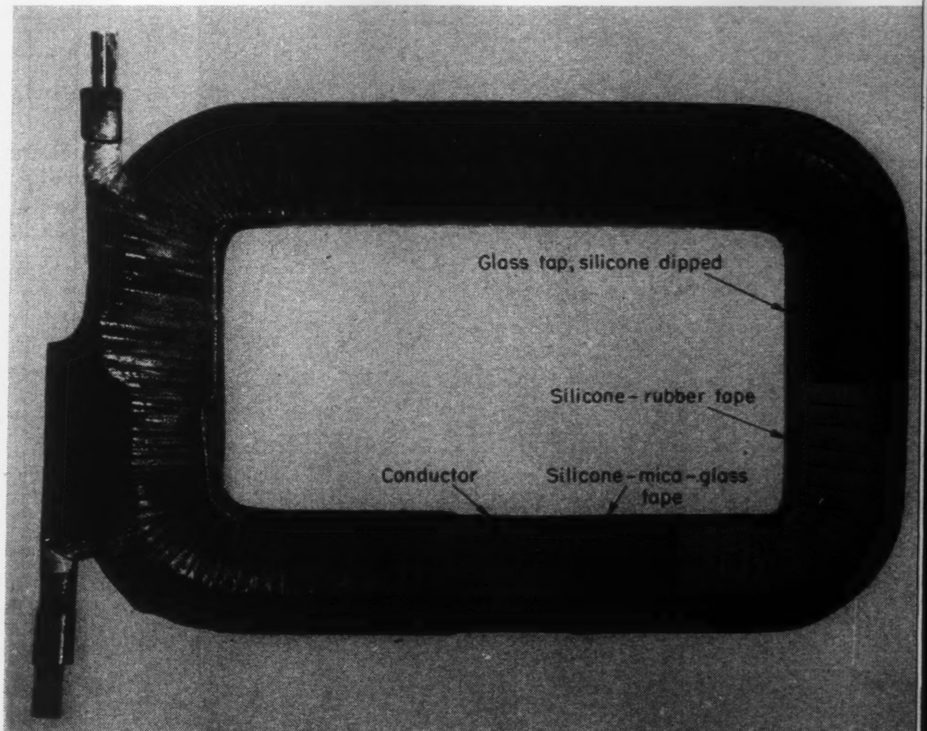
Temperatures ranging from −20 to 400 F have practically no effect on the power factors and very little effect on the dielectric constants of these fluids. Constants also remain practically unchanged at frequencies from 10^2 to 10^{10} cycles per second. Dielectric constant is in the range of 2.18 to 2.68 for fluids below 20 centistokes viscosity and 2.68 to 2.77 for higher viscosity fluids.

Dielectric strength of the fluids tested at 0.1-inch spacing according to ASTM D877-46T, is in the range of 300 to 500 volts per mil. Volume resistivity is about 10^{14} ohm-cm and remains relatively constant at temperatures up to 400 F.

Silicone fluids have found applications in mili-

Fig. 3 — Dielectric constant and power factor for a dielectric compound used for sealing and electrical insulation





Coil jackets of cured silicone-rubber tape are tough and resilient, with a high degree of resistance to moisture absorption, lubricating oils and a variety of chemicals. Dielectric properties at room temperature compare to those of resilient insulators and are superior at high temperatures

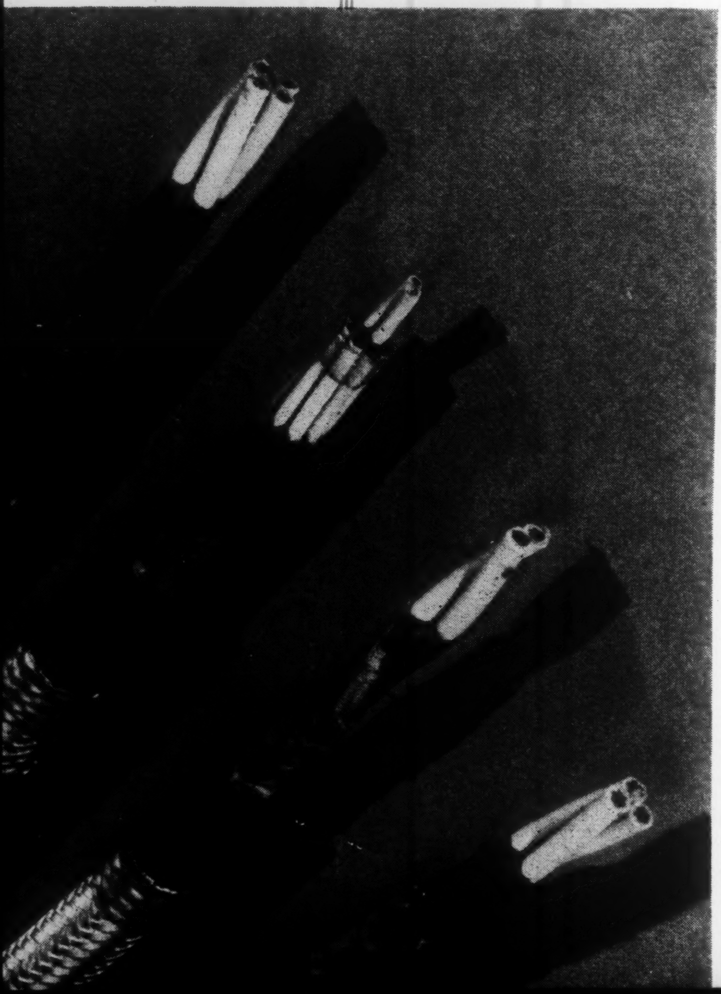
Table 4—Properties of Silicone Insulating Resins and Varnishes

Property	935	993	994	996	997	1089	1360
Solids content (%)	50	50	50	50	50	40	49
Color	Light straw	Light straw	Light straw	Dark brown	Dark brown	Dark amber	Dark amber
Specific gravity	1.00–1.02	1.00–1.02	1.00–1.02	1.00–1.02	1.00–1.03	1.05–1.10	1.13–1.14
Drying time, maximum	1 hr, 250 C	3 hr, 250 C	1 hr, 250 C	3 hr, 150 C	3 hr, 200 C	3 hr, 150 C	1 hr, 150 C
Weight loss, after 3 hr* (%)	5	7	7	4	5	23	10
Craze life, minimum* (hr)	800	1000	3000	750	1000	....	....
Flex life, minimum* (hr)	100	250	1000	250	250	....	....
Dielectric strength, 2-in. electrodes (v/mil)	1000–2000	1000–1500	1600–1900	1000–2000	1000–2000	1500	....

*At 250 C

Silicone-rubber insulation assures dependability in control and power cable produced to meet Navy specifications. Low-temperature flexibility, heat and moisture resistance, and excellent dielectric strength, are characteristic advantages of silicone insulation

Photo, courtesy Okonite Co.

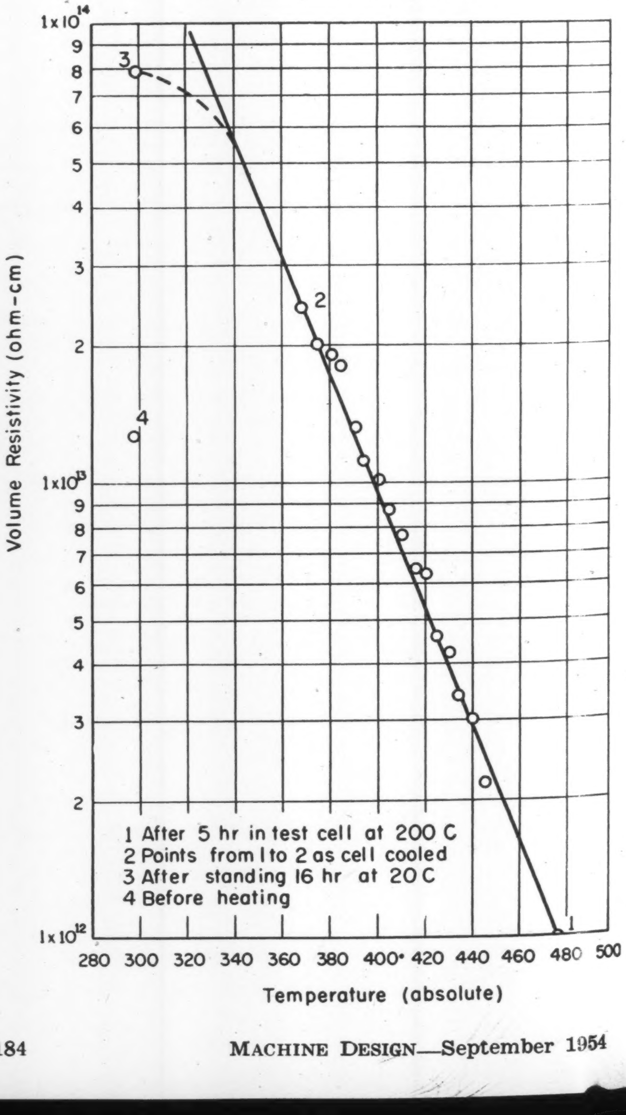


tary equipment where size and weight are of importance, including aircraft transformers, capacitors and sealed electronic assemblies.

Rubber: Silicone rubber has been called the closest known approach to the ideal dielectric. It combines the heat stability and moisture resistance of resinous silicones with many of the most desirable properties of rubber, and adds a few features of its own.

Thermal conductivity of silicone rubber is, for

Fig. 4—Volume resistivity of a dielectric compound



example, about 150 per cent of that of either organic resinous or rubber dielectrics. As indicated in *Fig.* 5, a silicone-rubber-insulated coil can operate at temperatures as much as 50 per cent below that of a silicone-resin-insulated coil under the same load.

As a cable covering, silicone rubber has excellent resistance to corona. Silastic insulated ignition wire shows no deterioration after 12,000 hours under test conditions that cause organic rubber covering to fail in 3 to 30 minutes.

As indicated in *Table* 1, the dielectric properties of typical silicone rubbers compare favorably at room temperature with those of conventional rubbers. There is little change in dielectric properties over a temperature span of from below zero to over 200 C. At elevated temperatures, organic rubbers deteriorate rapidly and become conductors rather than insulators. Even more important is the fact that high-temperature aging, *Fig.* 6, does not significantly alter the dielectric properties of silicone rubber.

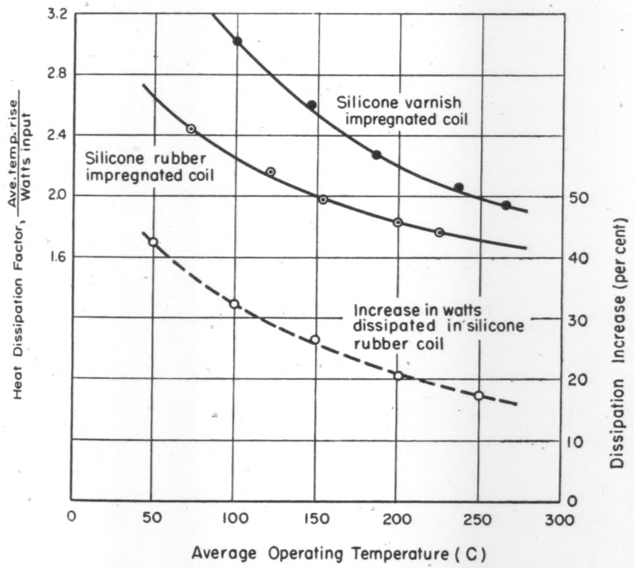
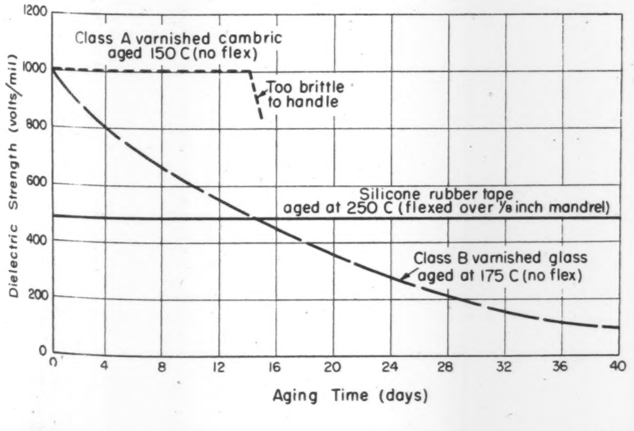


Fig. 5—Above—Comparison in heat dissipation for a silicone-rubber impregnated coil and a silicone-varnish impregnated coil (375 turns of No. 17 wire)

Fig. 6—Below—Change in dielectric properties of silicone-rubber impregnated tape as compared with conventional insulating tapes



Silicone rubber also has a high resistance to arcing and to electrical fatigue. Its water absorption values range from 6 to as low as 0.5 per cent, and it is unique in that even maximum absorption has no material effect on dielectric properties.

Silicone rubber is used in a variety of applications including wire and cable covering, capacitor and transformer bushings, and coil wrapping.

Resins: Class H or silicone insulation is one of several varieties which have been classified by the AIEE according to resistance to thermal aging. Of these, Class A is made up of organic components bonded with an organic varnish; Class B con-

Printed circuits etched on copper-clad, silicone-rubber-coated glass cloth offer easy installation and assembly of electronic equipment, as well as excellent service at high temperatures

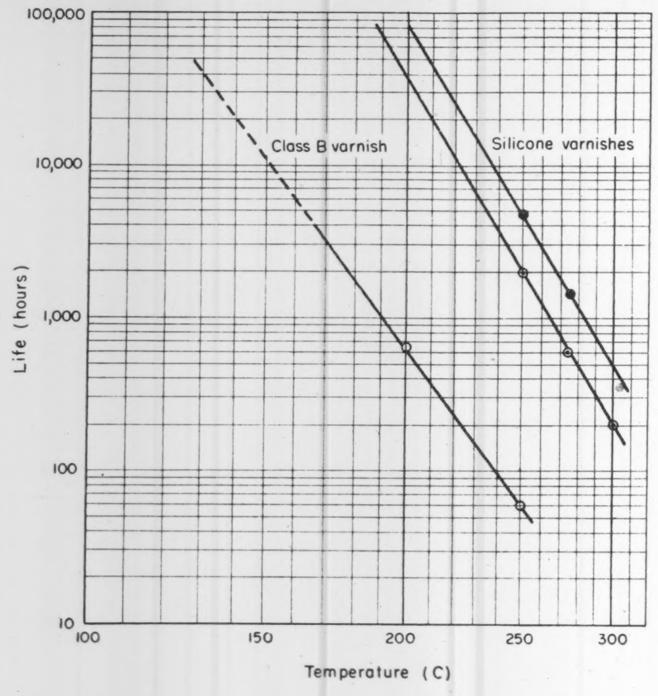


Fig. 7—Thermal life of silicone insulating varnishes based on 50 per cent retention of dielectric strength

sists of inorganic components bonded with an organic varnish; and Class H refers to "inorganic materials with bonding substances composed of silicones or materials with equivalent properties". Thus Class H insulation and silicone insulation are somewhat synonymous.

The AIEE has established a conservative 180 C as Class H hottest spot temperatures, although Navy specifications have raised that figure to 200 C.

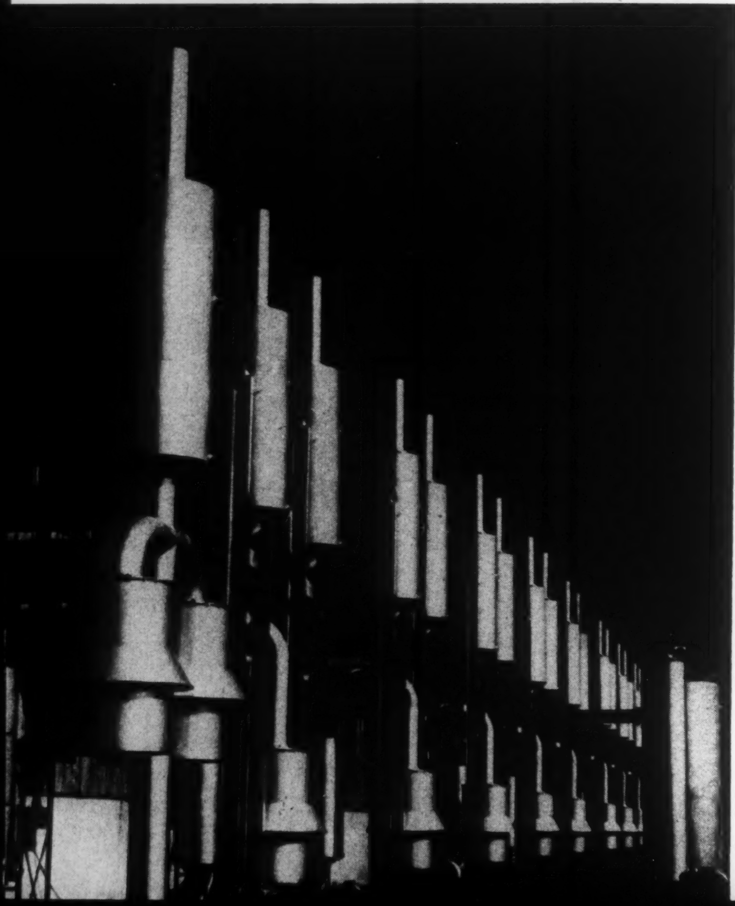
Silicone dielectrics used to make up Class H insulating materials may be divided into cloth-coating resins, dipping or impregnating varnishes, wire enamels, and bonding or laminating resins. Typical properties for leading members in the first three are given in *Table* 4. Thermal life of the leading silicone dipping varnishes as compared to Class B materials is indicated in *Fig.* 7.

The two silicone wire varnishes differ widely in application. One is specifically designed to bond single or double glass serving on copper magnet wire. Such magnet wire insulation has good abrasion resistance and remains serviceable for extended periods, largely because of the effect of the glass serving itself. The other is used as an enamel on bare magnet wire. With physical properties comparable to the better organic wire enamels, the silicone wire enamel has about the same life expectancy at 200 C as conventional organic enamels have at 105 C; flexibility and scrape abrasion resistance compare favorably; resistance to solvents, oils and salt water is substantially superior.

PROTECTIVE COATINGS

Broadly speaking, silicone protective coatings may be divided into three categories by vehicle content: 100 per cent silicone, silicone copolymers, and modified silicones. The 100 per cent, or straight, silicone finishes are most useful where temperatures range from 500 to 900 F and where there is severe weathering or exposure to corrosive atmosphere. Straight silicone finishes are also best if color stability, either upon exposure to outdoor weathering or to high temperature, is highly desirable.

Most silicone copolymers are made with alkyd



Two coats of aluminum paint based on a straight silicone vehicle withstand surface temperatures of 400 to 600 F on these gas compressor exhaust mufflers for three years service

Photo, courtesy Kansas Paint & Color Co.

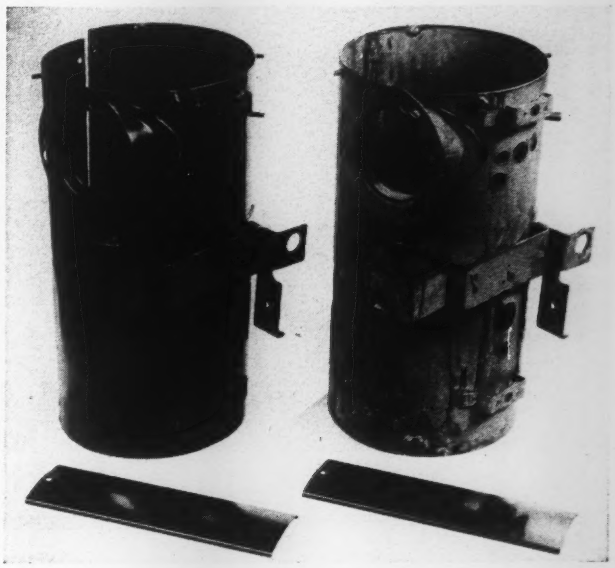
resins, although some developmental work is being done with the phenolics. The silicone-alkyds combine the weathering and heat-resistant properties of the silicones with the excellent adhesion and film properties characteristic of the alkyds. Used primarily in baking enamels for space heaters and other interior uses, the silicone-alkyds perform well in light-colored finishes at temperatures up to 450 F.

Modified silicones are an attempt to overcome some of the limitations of the straight silicones by cold-blending them with various organic resins. Poor solvent resistance, slow curing, slight thermoplasticity, and higher initial cost can all be minimized, but at the expense of certain other properties. In many cases, however, they do as well as straight silicones, and several of them provide better protection than a straight silicone in a temperature range of from 900 to 1200 F.

Water Repellents: Virtually all silicones are water repellent. They cannot all be used indiscriminately, however, in every application where a water-repellent characteristic might be desirable.

There are silicone water repellents available for textiles, leather, masonry, glass, ceramic and plastics. Another silicone water repellent also imparts an "abhesive" characteristic to paper and parchment, prevents the adhesion of sticky products and foods to treated wrappers. All of these water repellents offer the desirable advantage of allowing the treated material to breathe. That is, they provide water repellency without sealing off the pores.

Glass, ceramic and plastic electrical insulating materials are made water repellent with an air-drying silicone resin. It produces a smooth, transparent film which repels water and maintains high surface resistivity under humid conditions. The film is hard and weather resistant. It eliminates leakage currents and flashovers; reduces maintenance and extends the service life of insulators.



Relative heat and salt spray resistance of modified-silicone and organic-based finishes is contrasted in Ordnance heater shells. The shell on the left was sprayed with olive-drab modified-silicone paint and baked 30 minutes at 400 F. The one on the right was sprayed with conventional Army olive drab and baked 45 minutes at 250 F. Panels in the foreground show initial appearance of the finishes. Both shells were heated to 500 F for 4 hours. The organic coating was then subjected to salt spray for 100 hours, the silicone for 300 hours

Photo, courtesy South Wind Div., Stewart Warner Corp.

OILS AND GREASES

Oils and Fluids: Silicone oils, generally referred to as silicone fluids, have been under commercial development for little more than 10 years. Even so, their unusual properties have promoted their use in almost every field.

In general, silicone oils are heat-stable and resistant to oxidation, gumming and weathering. They have excellent dielectric properties, and relatively flat viscosity-temperature slopes, *Table* 5. They exert a virtually constant damping force over a wide range of temperatures, and are highly resistant to permanent shear breakdown. They are highly nonreactive and inert to metals, plastics, and most organic materials.

These properties make practical the use of silicone oils as damping, hydraulic or dielectric fluids,

Table 5—Properties of Silicone Fluids

Fluid	Viscosity (centistokes)	Viscosity-Temperature Coefficient*	Pour Point (F)	Flash Point (F)	Volatility at 500 F (per cent)	Gel Time at 500 F (hours)
200†	1.0	0.37	—123	100	Distils	Distils
200†	10.0	0.60	—67	575	5	24
200†	500	0.61	—58	600	5	24
510§	500	0.64	—70	525	9	400
550	150	0.76	—58	575	10	750
710	500	0.83	—8	600	15	1000

* (Viscosity at 210 F)/(Viscosity at 100 F). † Produced in viscosity range from 0.65 to over 1 million centistokes. § Produced in viscosity range from 50 to 100,000 centistokes.

Conveyor line carrying freshly painted electrical equipment through 375 F drying oven needs only two greasings a year with a silicone grease

Photo, courtesy Mullenbach Electrical Mfg. Co.

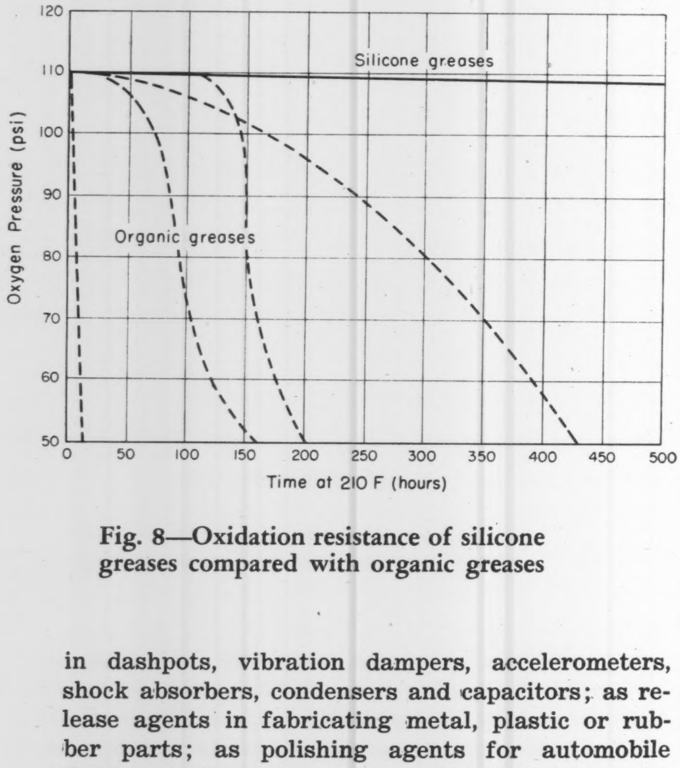


Fig. 8—Oxidation resistance of silicone greases compared with organic greases

in dashpots, vibration dampers, accelerometers, shock absorbers, condensers and capacitors; as release agents in fabricating metal, plastic or rubber parts; as polishing agents for automobile finishes and furniture; as defoaming agents for many nonaqueous systems and processes; and as heat-stable lubricants for many high temperature applications.

Greases: Silicone greases are formulated by combining various thickening agents with different silicone oils. Properties of these greases are determined by both the fluid and the thickener; therefore, both are selected to give optimum service in the applications for which the lubricant is designed. Data in *Table* 6 lists typical properties of the four types of silicone grease now available.

Of these four types, two are ball-bearing lubricants thickened with organic soaps. One is designed for extremely low temperature service; the other, for permanent lubrication of ball bearings operating at temperatures from −40 to 400 F. The third and most heat-stable silicone grease is thickened with a special carbon black and is used to lubricate oven conveyor bearings and kiln carts, regulator valves, compressor engine valves, furnace and oven doors, driers, and similar low-speed equipment. The fourth grease which is prepared by thickening a silicone oil with a finely divided silica filler is used primarily as a valve lubricant where steam, corrosive materials or heat cause rapid failure of organic valve lubricants.

Resistance of silicone greases to oxidation is indicated by results of oxygen-bomb tests shown in *Fig.* 8. Test conditions were 500 hours exposure to oxygen under pressure of 100 psi at 210 F, in the presence of a brass catalyst.

Compounds: Silicone compounds are made by combining silicone oils, and suitable thickening agents. The various silicone compounds include defoamers which are effective at very low concentrations in many aqueous and nonaqueous systems,

Table 6—Physical Properties of Silicone Greases

Type	ASTM Penetration	Apparent Density	Dropping Point (F)	Bleed* (per cent)	Evaporation* (per cent)
33 grease†	320	0.92	400	3.0	3.0
44 grease†	310	0.97	400	1.5	1.5
41 grease†	300	0.98	None§	4.0	1.0
Valve Seal A	240	0.98	None§	1.0	1.5

*Determined after 24 hours at 300 F in a wire mesh screen. †Produced in 4 different consistencies: fluid, light, medium and heavy. Properties are for the light consistency grade, used in most applications. §Do not fuse because greases contain inorganic fillers.

moisture-repellent and heat-stable dielectric materials, and release agents.

Inherent properties of silicones also make practical the use of such compounds as damping media; as antisqueak agents and lubricants for plastic and rubber parts; and as antiseize lubricants for hold-down bolts on high-temperature equipment.

ADHESIVES

Although most silicone products are so nonreactive that they make excellent release agents, a new compound has been developed which is notable for the tenacity with which it sticks to a wide variety of surfaces, including such relatively inert materials as polyethylene, tetrafluoroethylene, and even silicone-varnished glass cloth and silicone rubber.

The new product has an adhesive strength that compares favorably with that of conventional pressure-sensitive adhesives at room temperature. Furthermore, adhesive strength is retained over a temperature span ranging from −55 to over 300 F. Highly water repellent and resistant to weathering, oxidation and a variety of commonly used chemicals, the silicone adhesive also has excellent dielectric properties.

Glass-cloth tapes coated with this material are now used for high-temperature electric and electronic applications and for low-temperature, weather-resistant wrapping and sealing.

Pressure-sensitive tapes made with Dow Corning XC-269 or XC-271 silicones can be applied at temperatures ranging from —55 to 250 C and retain good adhesive strength after long exposure to these temperatures. These adhesives can also be used to join such "abhesive" materials as silicone rubber, silicone-treated paper, Teflon and silicone-glass laminates to metals, glass, paper or plastics

They Say . . .

"I cannot conceive of how a professional man who joins a union can also think of himself as a professional man. When he joins a union he delegates to the union leaders the right to bargain with his employers as to his remuneration and other working conditions. How much individuality in his vocation can a union man have? The engineer is really a part of management, because he manages methods and materials. Yet, when he joins an engineers union, as some engineers have done, he tells the public he does not wish to be regarded as part of management."—HARRY A. WINNE, *retired vice president, General Electric Co.*

"He who devotes sixteen hours a day to hard study may become as wise at sixty as he thought himself at twenty."—MARY WILSON LITTLE

"We use thousands of hours and millions of dollars in developing tools and machines. We use very little effort and very little money in developing man. The possibility of man however, is so far above the possibility of the machine tool or any tool, that there is no comparison.

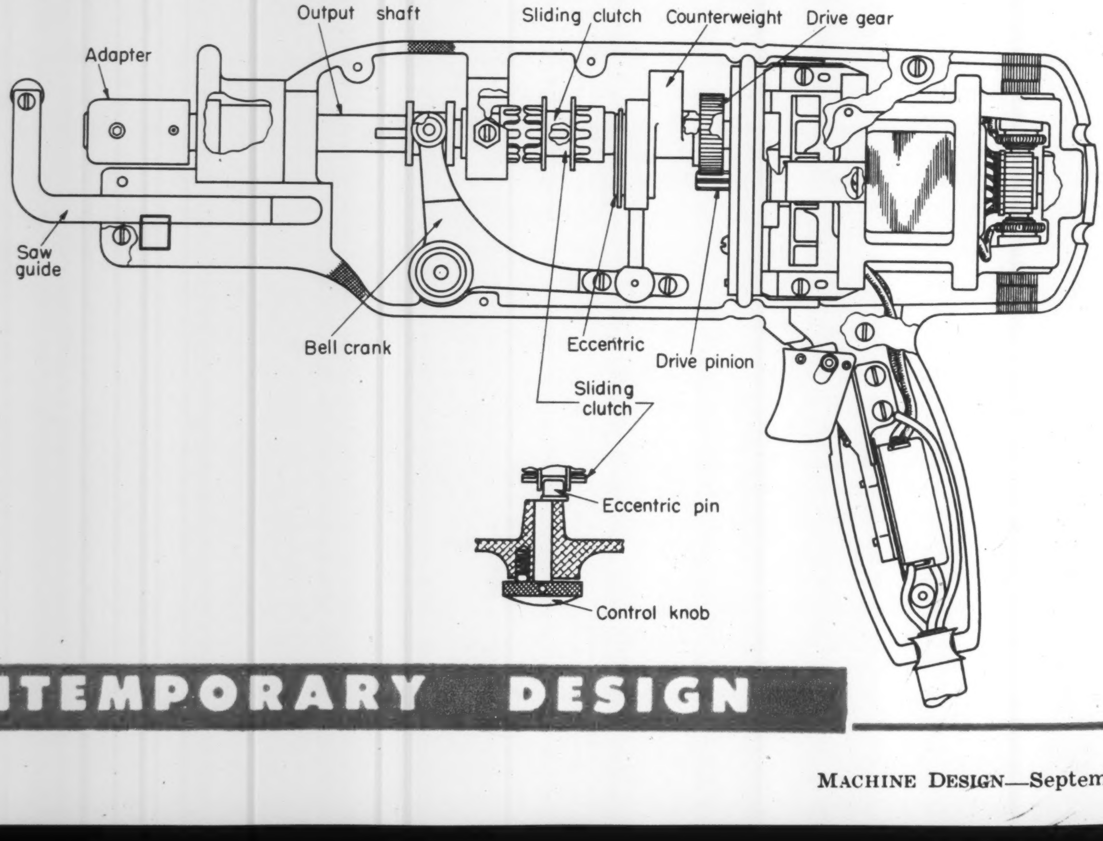
"The next great step we are going to take forward insofar as industry is concerned is to recognize that the greatest possibility is not in machines but is in that tremendous individual—man." — JAMES F. LINCOLN, *president, Lincoln Electric Co.*

Rotary or Reciprocating Motion Available From Saw-Drill

A NEW powered hand tool may be used as a drill, hack saw or flat filing machine. Output can be quickly changed from rotary to reciprocating motion or vice versa. Developing up to 1/5-horsepower, the Crown Trades Master saw-drill weighs seven pounds, has an average drilling speed of 1900 rpm and an average sawing speed of 1700 surface feet per minute. An aluminum case contributes to low weight of the tool.

CROWN
SAWDRILL

With the control knob at the position marked *D* for drilling, an eccentric pin at the end of the control shaft engages a sliding jaw clutch with the output shaft of the saw drill, causing the shaft to rotate. For drilling, the saw guide is turned downward or removed altogether and a three-jaw geared chuck with maximum capacity of ¼-inch is inserted in the adapter on the output shaft. With the control knob in the *S* or sawing position the eccentric pin on the control shaft moves the sliding jaw clutch to the rear to engage an eccentric, sleeved on the drive shaft. This eccentric revolves within a sleeve which is coupled to a bell crank by a rod. The bell crank connects to the drive shaft and imparts reciprocating motion. Stroke is 7/16-inch.


Output shaft
Sliding clutch
Counterweight
Drive gear
Adapter
Saw guide
Bell crank
Eccentric
Drive pinion
Sliding clutch
Eccentric pin
Control knob

CONTEMPORARY DESIGN

Design for Riveting

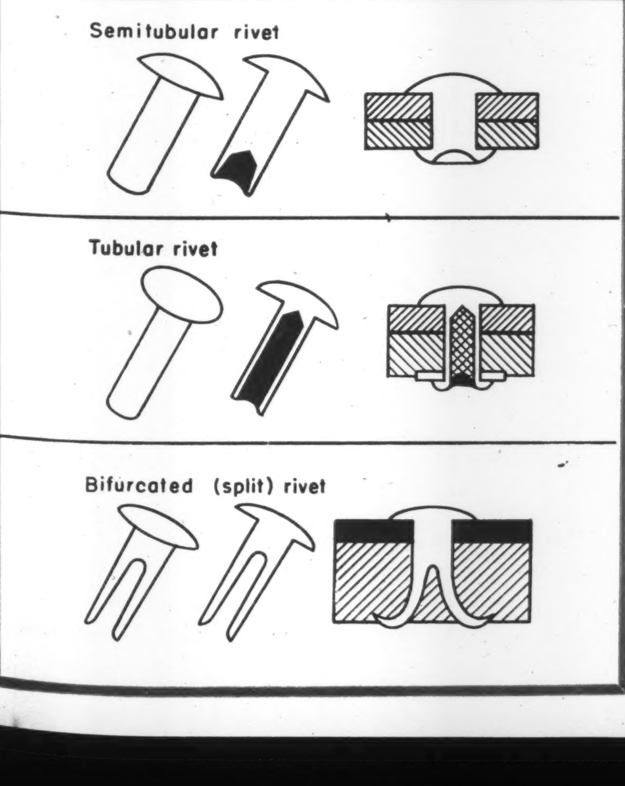
Small Rivets and Their Selection

By Roger W. Bolz
Contributing Editor, Machine Design

THE common small rivet can perform a variety of vital and important fastening tasks. Low in cost, rivets correctly applied can provide real service and production economies.

A wide variety of parts and materials may be successfully fastened with rivets. Die castings, sheet metals, plastics, canvas, plywood, cloth, leather, fiber, soft goods, composition materials, as well as combinations of these, may be riveted satisfactorily.

Fig. 1—Three basic types of standard rivets and fastened joint typical with each. Tubular rivets may be star or roll-set with or without the washer shown and, as with the split rivet, can be set with a cap



Small rivets are available in steel, aluminum, brass, copper, stainless, nickel, bronze, Monel, silver, and other materials. To suit the design requirements, plating or finishing can be specified. Brass, nickel, cadmium, copper, tin, zinc and oxodized platings are used. Japanning and other coatings are also provided.

Basic Rivet Styles: While solid rivets are available and widely used, it is usually necessary to hand-feed and upset such rivets in assembly. Tubular rivets, on the other hand, are eminently suited for use with high-speed automatic feed rivet setters, *Fig.* 1. Owing to the savings possible with such assembly equipment, tubular rivets offer outstanding possibilities in fastening with adequate strength for most purposes.

SEMITUBULAR RIVETS: One basic type of small rivet is the semitubular extruded or shallow-drilled design. This rivet is made with a shallow end impression which in the extruded types may be tapered. However, it is also provided with a straight-wall hole in many cases.

These rivets are primarily adapted for any assembly operation where holes have been drilled or punched prior to rivet setting. They provide full shear and strong clinch or set. Semitubular rivets are usually roll-set and are suitable for fastening plastics, wood, sheet metals, and similar materials. It is the most widely used rivet.

A variety of head styles are available in this design. Round, oval, flat, countersunk and shoulder types with any head style are typical.

TUBULAR RIVETS: Full tubular rivets are deep-drilled to be self-piercing. They are mainly suited for fastening soft materials such as plastics, leather, wood, canvas, cardboard, pressed wood, or any other material which can be pierced by the rivet when set. These rivets are generally star or roll-set and can be used with caps or crowns.

Table 1—Standard Clinch Allowances

Rivet Shank Diam. (inches)	0.060	0.065	0.088	0.098	1/8	9/64	5/32	3/16	1/4
Clinch Allowance (inches)									
Semitubular	0.032	0.032	0.045	0.055	0.062	0.093	0.093	0.125	0.156
Split & Full Tubular	....	....	0.062	0.078	0.093	0.125	0.125	0.156	0.187
Aluminum Tubular	0.045	0.045	0.062	0.078	0.093	0.125	0.125	0.156	0.187
Hole Size									
Diameter (inches)	0.067	0.070	0.093	0.104	0.128	0.152	0.165	0.196	0.265
Drill No.	51	50	42	37	30	24	19	9	17/64

Full tubular deep-drilled rivets are generally available with round, oval, flat, and countersunk-head styles.

BIFURCATED RIVETS: The bifurcated or split rivet is formed by slotting a solid rivet. Splitting is done by punching or milling. Used mainly for fastening soft materials, the punched type is best for light fastening such as cardboard, canvas, fabrics, leather, etc. The milled type is stronger and sharper and can be used in fiber, wood, light sheet metal.

As with deep-drilled rivets, the split type pierces its own hole while being set. Head styles include round, oval, flat, and countersunk.

SPECIALS: All manner of special rivet designs are available for unusual applications. Basic types

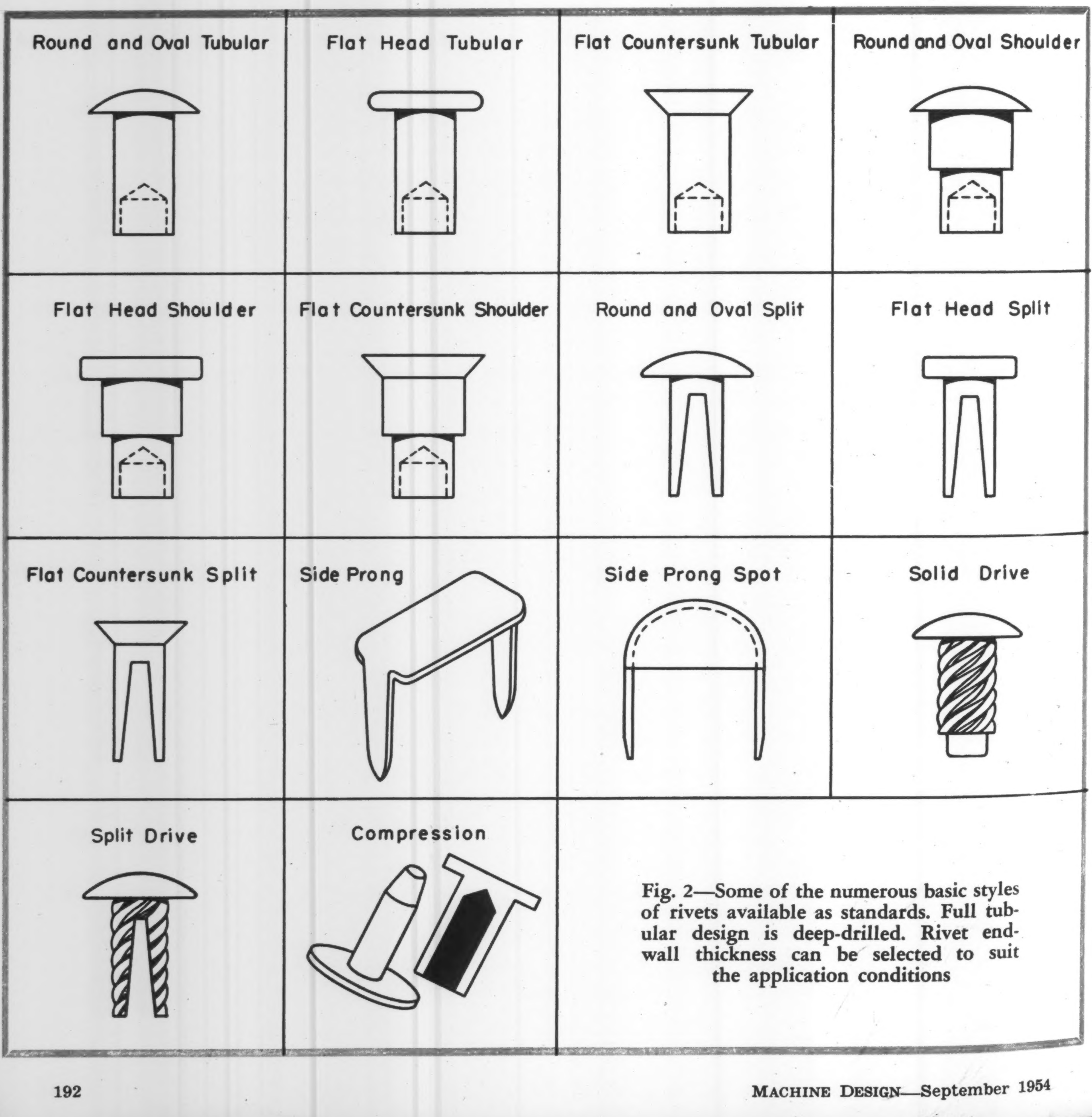

Round and Oval Tubular
Flat Head Tubular
Flat Countersunk Tubular
Round and Oval Shoulder
Flat Head Shoulder
Flat Countersunk Shoulder
Round and Oval Split
Flat Head Split
Flat Countersunk Split
Side Prong
Side Prong Spot
Solid Drive
Split Drive
Compression

Fig. 2—Some of the numerous basic styles of rivets available as standards. Full tubular design is deep-drilled. Rivet end-wall thickness can be selected to suit the application conditions

are made with special head styles such as decorative caps, hollow heads, projections, etc.

Besides the regular styles available as standards, there are a variety of other rivet types which can be procured from stock although not from all sources. Side-prong rivets are made in a variety of head styles and shapes for functional and decorative purposes.

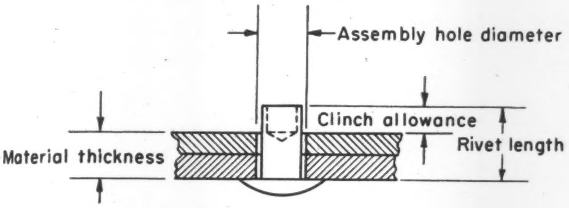


Fig. 3—Rivet joint arrangement showing terminology. Typical values are shown in *Table* 1

In addition, drive rivets can be used. These are made with spiral serrations on the body and come in solid body with tenon end or split design. Rivets of this design are generally employed for riveting into blind holes where the fastener cannot be set. Many head styles and shapes are produced and include round, oval, countersunk, shoulder head, and other styles including some with tapped holes.

For other special applications, compression rivets are supplied. These are a combination of a solid and a deep-drilled rivet to obtain a finished or flush head on each side.

Rivet Sizes: A few of the many types of common rivets are shown in ***Fig.*** **2**. Sizes range from the smallest with a shank or body diameter around 0.058-inch to ¼-inch. Lengths depend upon the shank size and range from 3/32-inch, the smallest, to ⅝-inch, the largest. Length increments generally increase in 1/32-inch steps up to ⅜-inch and in 1/16-inch steps over this length.

Holes and Rivet Length: To determine the proper hole size for semitubular rivets, 7 per cent of the rivet shank diameter is added. Thus, the proper hole is equal to 1.07 times the shank diameter. This can normally be adjusted slightly where necessary to permit use of a standard drill or punch.

To determine proper rivet length for semitubular rivets, 70 per cent of the shank diameter is added to the total compressed material thickness, ***Fig.*** **3**. In *Table* 1 are given some standard clinch allowances for general purposes. To find rivet length, combined material thickness is added to the clinch allowance and the next higher closest applicable length of standard rivet selected.

ACKNOWLEDGEMENT

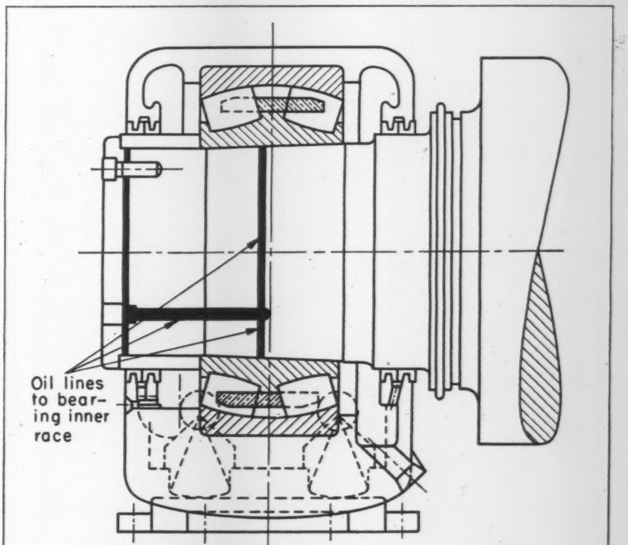
Assistance of the following companies in the preparation of this article is acknowledged with appreciation:

Chicago Rivet & Machine Co. (*Fig.* 3, *Table* 1)	Bellwood, Ill.
E. B. Stimpson Co. (*Fig.* 2)	Brooklyn, N. Y.
Milford Rivet & Machine Co. (*Fig.* 1)	Milford, Conn.
Judson L. Thomson Mfg. Co.	Waltham, Mass.

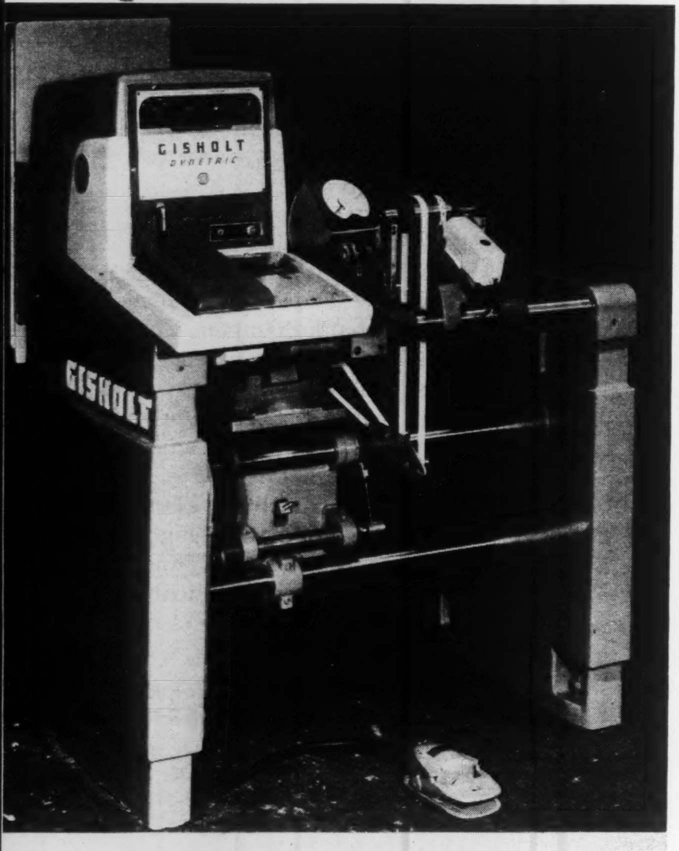
Hydraulic Pressure Simplifies Bearing Removal

REMOVAL of large press-fitted antifriction bearings can be a difficult and time-consuming procedure when ordinary bearing removing tools are used. It is, in fact, so difficult that, in certain instances, bearings which should have been press-fitted have been loosely fitted to permit easy removal. Wear and scoring of bearing bore and the mating surface of the shaft ensue. Development of a removal system using hydraulic pressure by SKF Industries Inc. is said to allow easy removal of the most tightly press or shrink-fitted bearings and, therefore, permits use of properly fitted bearings regardless of size or other circumstances.

Essentially, the system consists of drilling and grooving the shaft to allow oil under pressures of 5000 to 25,000 psi to be forced between the contacting surfaces of a shaft and inner bearing race. Pressure distribution between the two surfaces is much higher at the ends or sides of the inner race and effectively retains the oil between shaft and race until the race has been expanded sufficiently to permit easy removal. Experiments conducted by SKF indicate that this removal method reduces friction between the contacting surfaces to 1 or 2 per cent of its original value. Necessary hydraulic pressure can be supplied by small, portable, manually-operated pumps.



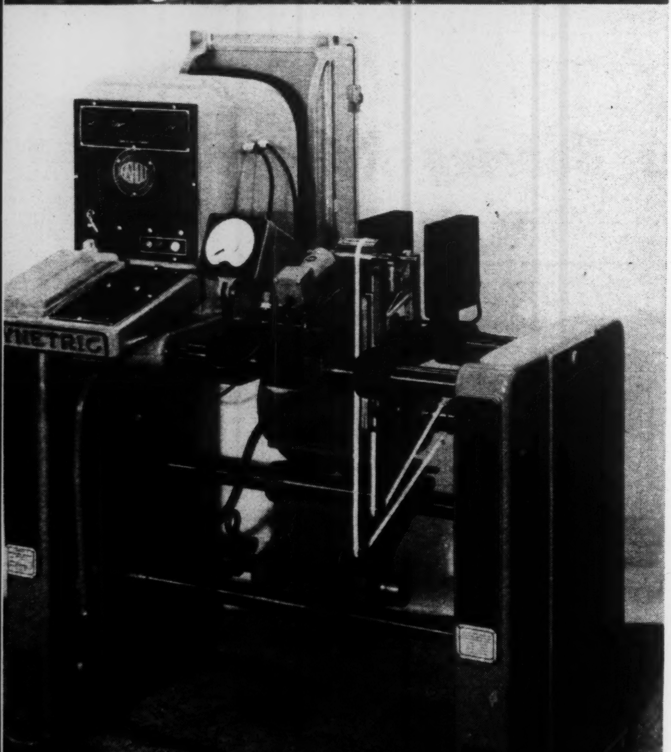
Redesigned Balancing Machine Has Improved Appearance

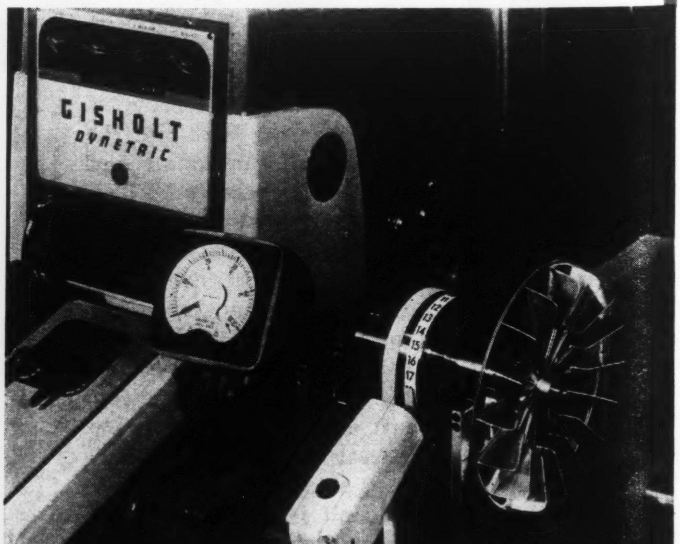


FIRST introduced in 1935, Gisholt Machine Co.'s Type S line of Dynetric balancing machines have recently been redesigned—mechanically, electronically and esthetically. Cost of the new electronics package is approximately 63 per cent of that of the original. At the same time, speed range and sensitivity of the electronic unbalance detection unit have been improved. Unbalance can now be detected over a much broader speed range, and vibrations exceeding 0.000025-inch in amplitude can be detected. Mechanical design has been improved by reducing the number of parts, and incorporating parts with multiple functions.

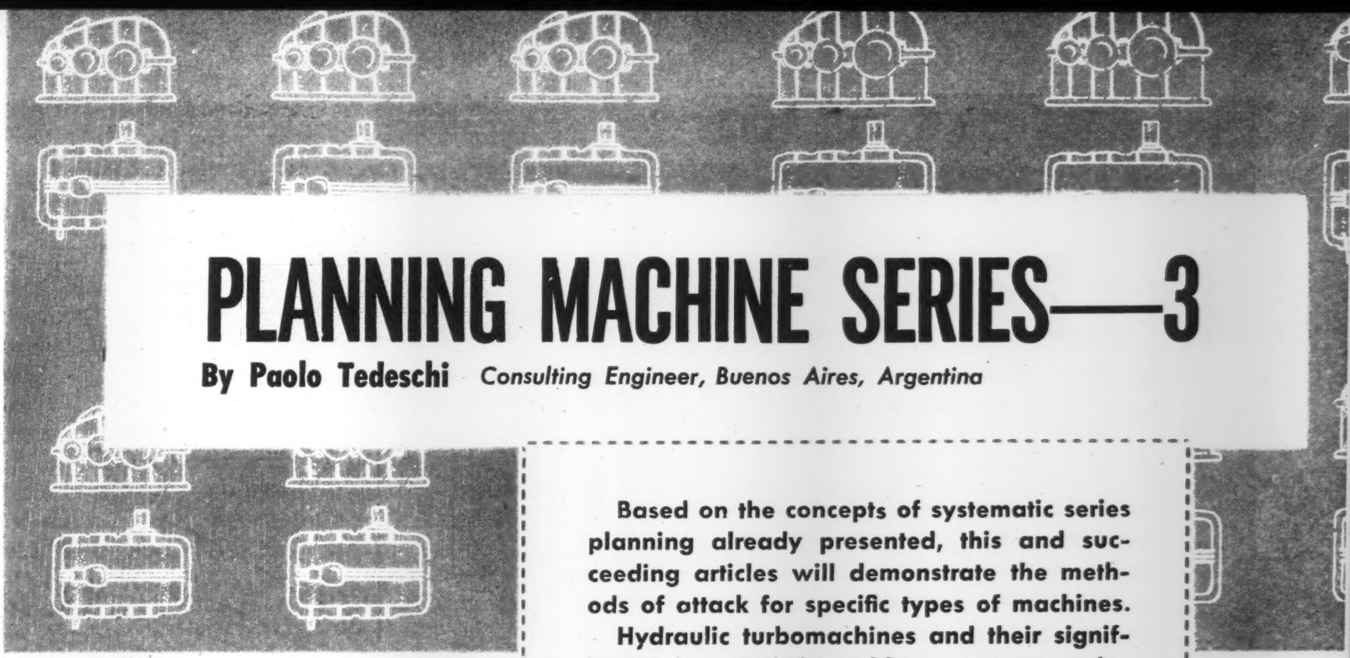
Dramatic emphasis has been placed on new features. With styling and color selection by J. M. Little and Associates working with Gisholt engineers, the machine has a unified, efficient appearance through balancing of form, mass and proportion, and the judicious use of color. Machine tool gray, accented with buff, is complemented with smooth anodized aluminum areas pointed up with red and black.

Control location and operation have been "humanized." Meters and dials have been located and designed—and relationship of color and pattern worked out—so that readings may be made quickly and accurately. Use of an indicating meter with a 270-degree scale also contributes to more accurate readings.





CONTEMPORARY DESIGN



PLANNING MACHINE SERIES—3

By Paolo Tedeschi *Consulting Engineer, Buenos Aires, Argentina*

Based on the concepts of systematic series planning already presented, this and succeeding articles will demonstrate the methods of attack for specific types of machines.

Hydraulic turbomachines and their significant characteristics with respect to series planning are discussed in this article; succeeding articles will treat other machine types. Emphasis will be given to those techniques and procedures offering widest utility.

BASIC laws governing the operation of hydraulic turbomachines are well-established. However, in spite of their similarity in origin and meaning, the fundamental expressions relating geometrical and operational characteristics of these machines often appear under different forms in the literature. To aid understanding, it will perhaps be best to establish first the forms of these basic laws as they will be adopted in these articles. Symbols are defined in the accompanying *Nomenclature*.

Nomenclature

D = Reference diameter of impeller defined in *Fig.* 11, ft
g = Acceleration due to gravity, 32.2 ft per second per second
H = Head, ft of fluid
n = Subscript notation designating normal or design operating point
p = Pressure, pounds per square foot
P = Power, hp
P_w = Output power, hp
q = Volume rate, cubic ft per second
q_h = Specific volume rate defined by Equation 46
v = Tip velocity of impeller, fps
γ = Specific gravity of fluid, pounds per cubic foot
ϕ = Volume coefficient
ψ = Head coefficient
ω = Angular velocity of impeller, rpm
$\omega_r = \omega/\omega_s$ = Speed ratio
ω_s = Specific speed defined by Equation 45

In terms of the impeller design tip speed (linear), v_n, these basic laws are:

$$q_n = \phi D^2 v_n \qquad (31)$$

$$H_n = \psi \frac{v_n^2}{2g} \qquad (32)$$

$$p_n = \psi \gamma \frac{v_n^2}{2g} \qquad (33)$$

In terms of rotational design speed (angular), ω_n,

$$q_n = \frac{\pi}{60} \phi D^3 \omega_n \qquad (34)$$

$$H_n = \frac{\pi^2}{7200g} \psi D^2 \omega_n^2 \qquad (35)$$

$$p_n = \frac{\pi^2}{7200g} \psi \gamma D^2 \omega_n^2 \qquad (36)$$

The dimensionless coefficients ϕ and ψ are characteristic of each particular type of machine and provide a picture of actual performance as related to the performance of an ideal machine, with allowance for actual flow and hydrodynamic losses. For a first approach, and particularly for the initial planning of a machine line, ϕ and ψ must be considered as constant for geometrically similar machines or for the same machine operating under various speeds.

Expressed proportionally, the relationships of Equations 31 through 36 thus take the more fa-

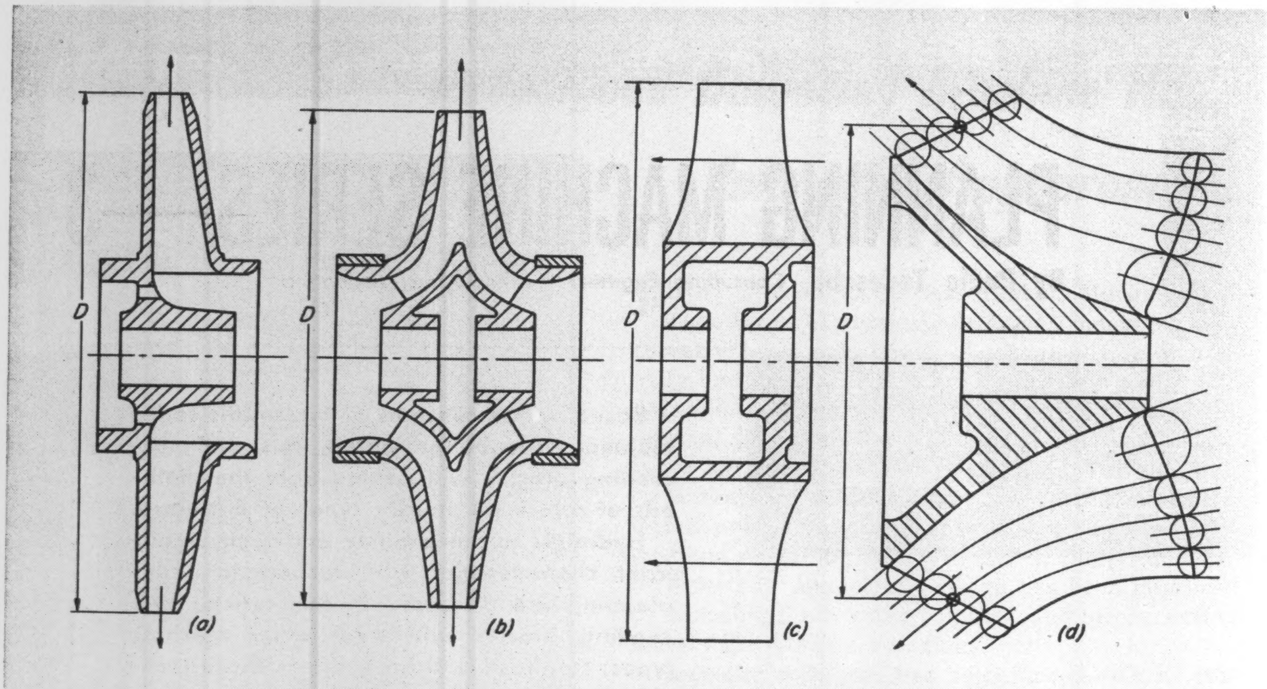


Fig. 11—Typical pump impeller designs showing reference diameter dimension *D* for: *a*, centrifugal unilateral type; *b*, centrifugal bilateral type; *c*, pure axial type; and *d*, mixed-flow type

miliar forms given by the expressions,

$$q \propto D^2 v \qquad (37)$$

$$H \propto v^2 \qquad (38)$$

$$p \propto v^2 \qquad (39)$$

$$q \propto D^3 \omega \qquad (40)$$

$$H \propto D^2 \omega^2 \qquad (41)$$

$$p \propto D^2 \omega^2 \qquad (42)$$

where $\propto$ is the symbol of proportionality.

In these general laws of similarity, the diameter D has the characteristic of a linear dimension representing the "size" of the machine. It could be replaced by any other linear dimension among those in a homothetic (similar) series of machines that are interrelated by strict proportionality. For example, in a series of homothetic low-pressure centrifugal fans, it would be possible to substitute for D one of the sides of the rectangular discharge port, or the square root of the port area, and so on, without detracting in any way from the value of the general laws. However, among these equally applicable dimensions, the impeller diameter is the most representative because of its direct relation with the operating data of the machine and may therefore be taken as the geometrical module of a line of homothetic machines.

The universal applicability of the impeller diameter as a geometrical module is further demonstrated by the fact that in certain cases, such as the centrifugal designs of *Figs.* 11*a* and *b*, this dimension establishes a surface of equal potential, while in others, as typified by the axial unit in *Fig.* 11*c*, the cylindrical surface of diameter D is the outside limit of the flow channel. In some instances, the conventional diameter has an intermediate character, for example, mixed-flow pumps, *Fig.* 11*d*. For the latter case, the geometrical module becomes the diameter determined by the point on the discharge edge of the vanes that divides the flow channel into two paths of equal volume rate.

If the tip speed v appearing in Formula 37 is constant, this expression represents the basic law of a line of homothetic machines which operate under constant linear velocity and furnish pressures in accordance with Formulas 38 and 39. This law is applicable to the design point or to any other operating point, which is related to the design point on a fixed percentage basis, in the areas of reduced or excessive load conditions. Thus, in Formulas 37 through 42 only general symbol notations have been used; design point subscript referances have been omitted.

In Formulas 40 through 42, if ω is kept constant, these expressions represent the laws of a series of homothetic machines operating under the same rotational speed.

From Formulas 37 through 42, the laws of similarity of power can be directly derived on the basis of the products, qH or qp. Thus, in terms of linear tip velocity,

$$P \propto D^2 v^3 \qquad (43)$$

and in terms of angular speed,

$$P \propto D^5 \omega^3 \qquad (44)$$

If it is assumed that efficiency is constant regardless of variations in D, v or ω, these formulas are equally useful for the fluid power or output of the machine as well as for its input. However, this assumption is only useful as a rough first approach because the actual rate of variation of flow and head losses, on which efficiency depends, is higher than that of ϕ and ψ due to the variables D, v and ω. Therefore, Formulas 43 and 44 could be expected to furnish more realistic results for outputs than for inputs.

On the same basis as for the other sets of related expressions, Formulas 43 and 44 represent the basic laws of similarity of power for a homothetic series or for a single machine operating under various speeds, depending on the kinematic or geometric dimensions which are maintained constant.

The specific speed, ω_s, of an operating turbomachine, defined by

$$\omega_s = \omega \frac{q^{1/2}}{H^{3/4}} \quad \text{(45)}$$

represents a characteristic of the particular basic turbomachine design. Substituting in this equation the expressions for q and H from Formulas 40 and 41 gives

$$\omega_s \propto \omega \frac{D^{3/2}\,\omega^{1/2}}{D^{6/4}\,\omega^{6/4}}$$

or ω_s = constant. This expression shows that ω_s is constant for all of the machines of a homothetic series and, therefore, is a characteristic of the particular type and design of turbomachine, irrespective of absolute size and operating speed. With few exceptions, the numerical value of this constant is alone sufficient to give a specialist in the subject a picture of the design and construction features of all of the machines of the line. As an exception, for example, equivalent specific speed values may exist for a conventional unilateral impeller (*Fig.* 11*a*) and a bilateral one (*Fig.* 11*b*) if the specific speed of each half of the bilateral type is equal to that of the unilateral one divided by the square root of 2. Also, certain narrow mixed-flow impellers, like those adopted in modern deepwell pumps, have the same specific speed value as some Francis type centrifugal wheels.

Specific Volume Rate: The specific volume rate, defined by

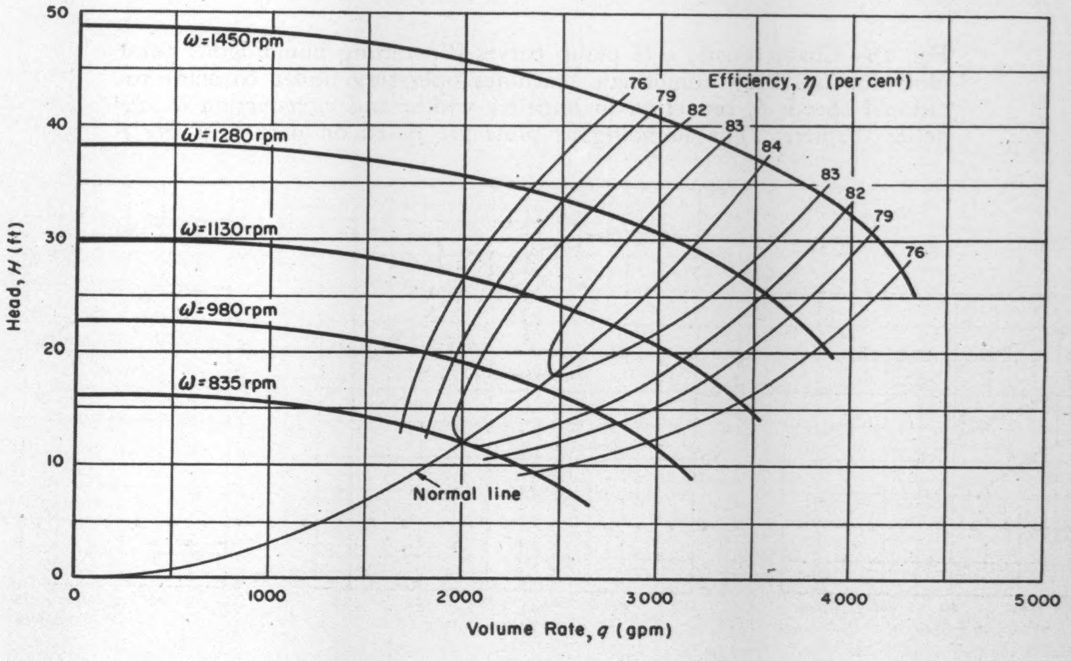
$$q_h = \frac{q}{\sqrt{H}} \quad \text{(46)}$$

is the operational characteristic of each machine in the series. If the expressions for q and H given by Formulas 40 and 41 are substituted in Equation 46, an expression in terms of the geometrical index D is obtained:

$$q_h \propto D^2 \quad \text{(47)}$$

This result indicates that when a machine operates under various speeds, its volume and head change but in such a way that the value of q_h from Equation 46 remains constant. Thus, q_h may be

Fig. 12—General performance chart for a mixed-flow pump



logically considered as an operational module for operating turbomachines, in accordance with the definition given in the first article of this series (July, 1954).

Referring q_h to the design point and adopting for q_n and H_n their complete expressions, Equations 34 and 35, gives

$$q_h = \sqrt{2g}\left(\frac{\phi}{\sqrt{\psi}}\right)D^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (48)$$

where the quantity multiplied by D^2 is a characteristic of an established series of machines. The basic design of the series is identified by the volume and head coefficients ϕ and ψ. The size of each machine is indicated in Equation 48 by the outside diameter D, which thus takes the function of a geometrical module. Therefore, Equation 48 constitutes a relationship between the operational and the geometrical modules of the general form of Equation 1 anticipated in the first article of this series: $W = kL^{\epsilon}$. In this case, the operational module W is the specific volume rate, the geometrical module L is the diameter, the exponent ϵ is equal to 2, and the constant factor k, if dimensions are consistent, is $\sqrt{2g}\ (\phi/\sqrt{\psi}\ )$.

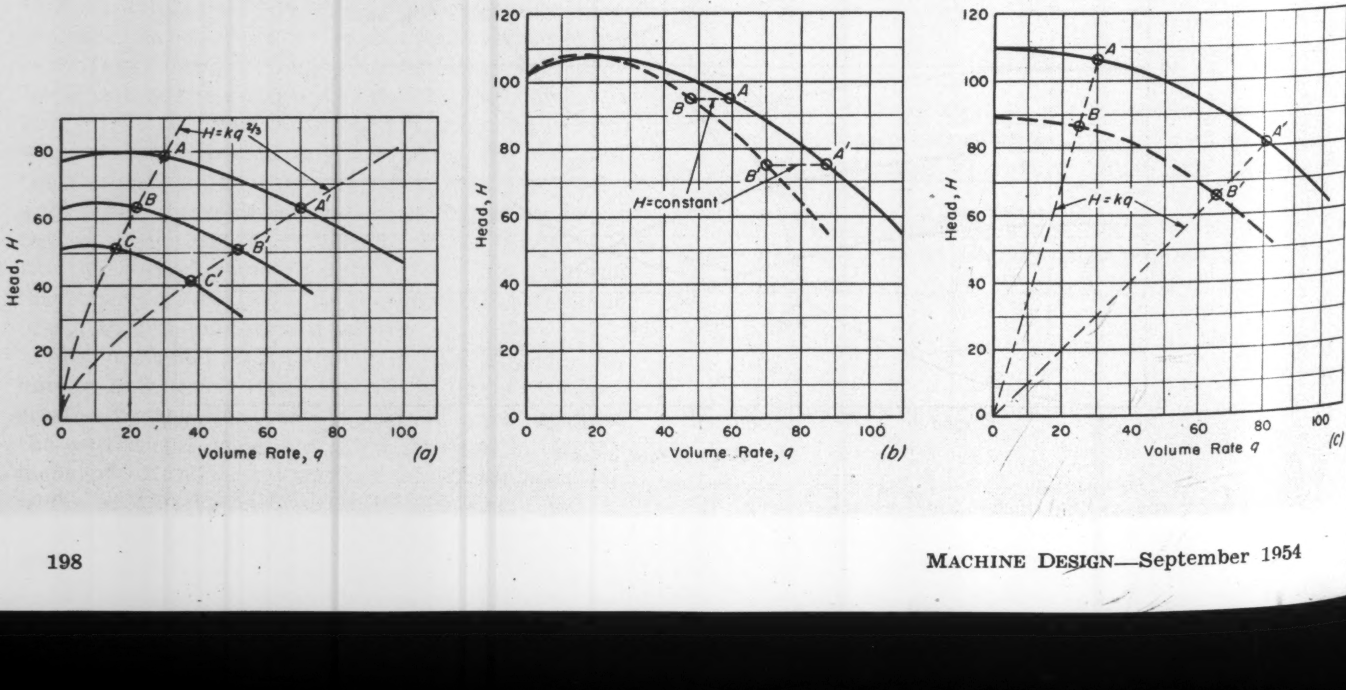
Specific volume rate, q_h, also has an important physical significance. In effect, as demonstrated by a general performance chart, *Fig.* 12, a line connecting the normal points of a machine operating under various speeds describes a curve closely similar to a parabola having its axis coincident with the axis of the H ordinates, the same curve given by the expression for q_h, Equation 46. Departure of the analogous experimental curve from the theoretical parabola is one of the many consequences of the fact that the different laws are merely limit laws, exactly fulfilled only by ideal machines. In dealing with practical examples, it will be shown when these departures have to be taken into account and how they may be foreseen.

Table 8—Similarity Laws for Hydraulic Turbomachines

Case	Basic Relationships	Curve Function $H = f(q)$
1. One machine, operating under variable rotational speed, ω. Geometrical dimensions are constant.	$q_h =$ constant $q \propto \omega$ $H \propto \omega^2$ $P \propto \omega^3$	$H = kq^2$
2. Several homothetic machines, operating under the same rotational speed, ω. Ratios between homologous dimensions are constant. Geometrical dimensions vary.	$\omega_s =$ constant $\omega_r =$ constant $q_h = D^2$ $q \propto D^3$ $H \propto D^2$ $P \propto D^5$	$H = kq^{2/3}$
3. Several homothetic machines, operating under the same tip speed, v. Ratios between homologous dimensions are constant; geometrical dimensions vary.	$H =$ constant $\omega_s =$ constant $q \propto D^2$ $n \propto D^{-1}$ $P \propto D^3$	$H =$ constant
4. One simple centrifugal machine with varying reduction in impeller diameter D, only. Other dimensions and rotational speed, ω, are constant.	$q \propto D^2$ $H \propto D^2$ $P \propto D^4$	$H = kq$
5. One simple centrifugal machine with varying reduction in impeller width, w, only. Other dimensions and rotational speed, ω, are constant.	$H =$ constant $q \propto w$ $P \propto w$	$H =$ constant

Impeller Reduction: Although the foregoing laws, which are of strictly rational origin, have a universal nature and may be applied to any type of

Fig. 13—Characteristic *q-H* pump curves illustrating homologous point plots for: *a,* three homothetic machines operating under constant rotational speed; *b,* reduction in impeller width; and *c,* reduction in impeller diameter. The homologous plots are based on data in *Table* 8



turbomachine practically without limitations, the considerations treated in the following discussion are only applicable to simple centrifugal or radial machines with certain design features and under limited conditions.

These considerations involve changes of performance that may result in such machines through reduction of the impeller diameter or width, or of both dimensions at the same time. However, in spite of the limitations and the empirical character of the corresponding relationships, impeller reduction has an economical and practical importance in tracing turbomachine series since this operation allows inexpensive filling-in of gaps between fundamental models and thus reduces the number of types in a series or permits the performance of standard models to be adapted to unforeseen requirements in lieu of introducing new models.

Theory and experience are in agreement that the volume, head and power for a pure radial (centrifugal) impeller, which operates at constant angular speed, change with diameter *D* and width *w* according to the general expressions

$$q \propto D^2 w \quad (49)$$

$$H \propto D^2 \quad (50)$$

$$P \propto D^4 w \quad (51)$$

As previously indicated, these formulas may be applied only to (1) a reduction of diameter, keeping *w* constant, or conversely to (2) a change of *w*, maintaining *D* constant, or to (3) variations in both where the operations are performed concurrently.

The preceding laws of reduction are closely fulfilled in practice if the impeller vanes are traced according to a logarithmic spiral and if the geometrical relations between the impeller and the volute suffer no appreciable modification when the tip of the impeller is machined off. Unfortunately, however, this condition is but rarely the case, and the largest permissible reduction is ordinarily 10 per cent of the original diameter.

Graphical Techniques: In *Table* 8, some of the more important laws for the tracing of turbomachine lines have been collected. As a basis for representation of these relationships on a *q-H* chart, such as the one in *Fig.* 12, the general shape of the curve corresponding to the law relating *q* and *H* in each particular case has been indicated in the right-hand column.

The first case confirms the principles previously discussed in conjunction with the behavior of a single machine operating under several different speeds. On a conventional *q-H* chart, homologous point plots describe parabolas having axes coinciding with the *H* axis of the chart, *Fig.* 12.

The second case indicates that homologous points of machines of the same homothetic line lie along parabolas having an exponential value of 2/3, *Fig.* 13*a*.

From Cases 3 and 5, it is apparent that constant peripheral speed machines, as well as those derived from each other by reduction in impeller width, form constant pressure series; their homologous points are found along constant ordinates, *Fig.* 13*b*.

Finally, the fourth case gives the homology of impeller diameter reduction. The direct proportionality existing between corresponding *q* and *H* values indicates that, as a result of diameter transformation, point plots are translated according to a projection from the axis origin, *Fig.* 13*c*.

All the expressions relating *q* and *H* are monomial with *q* raised to an exponential power. On a logarithmic *q-H* chart, these expressions appear as straight lines, variably inclined according to the exponent of *q*. The affinity between the *q-H* curves

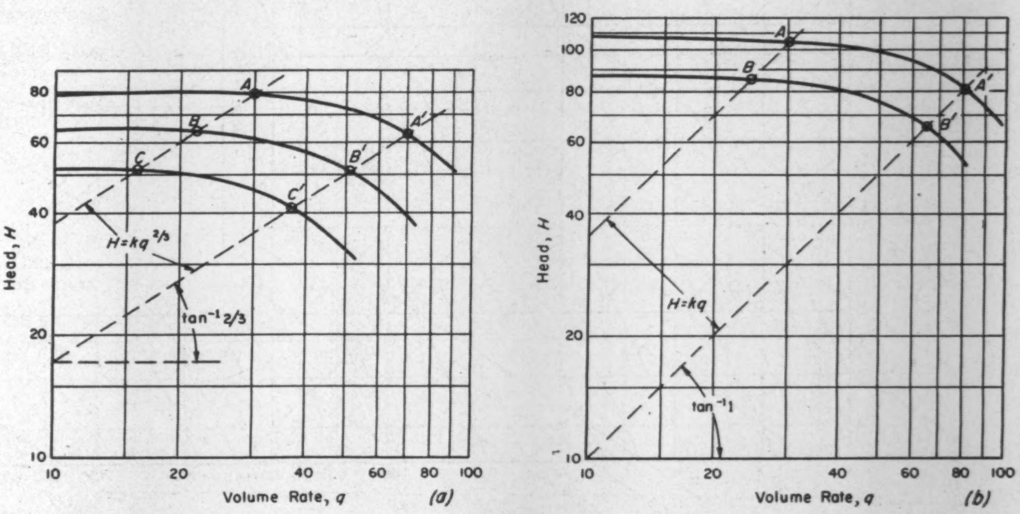


Fig. 14 — Logarithmic *q-H* charts showing corresponding logarithmic images for the characteristic curves and homologous point plots of *Fig.* 13*a*, at *a*, of *Fig.* 13*c* at *b*. Homologous curve functions appear as straight lines with varying slopes

is represented simply by translation of the individual curve points along the sloped lines. The slope of these lines is given by the exponent of q in the function, $H = f(q)$, and is equal to 2 for the case of a single machine with variable rotational speed and constant dimensions (q_h = constant); to 2/3 for the homothetic series (ω_s = constant), *Fig.* 14*a*; to 1 for the case of machines with reduced impeller diameter, *Fig.* 14*b*; and to 0 for the cases involving constant tip velocity and reduction in impeller width.

For concise graphical evaluation of a series of turbomachines under study, and to provide a basis for critical analysis of existing series, an extensive q-H logarithmic chart, as shown in *Fig.* 15, is necessary. In this chart, together with the basic scales of q and H, three additional families of parallel scale lines have been developed. The first of these families is made up of the lines representing the relationship, q_h = constant, in accordance with the concepts previously discussed. The second family are loci of points of constant power output, P_w, and are formed by lines, inclined at 45 degrees, which extend in a direction from the upper left-hand to the lower right-hand corners of the chart. These lines are clearly the logarithmic images of the equilateral hyperbolas given by the general expression: $P_w = qH$ = constant.

In the case of the expression, ω_s = constant, definite indication is impossible on this chart since more than one characteristic index may correspond to a single point. In effect, the same pressure and volume data may correspond to machines of different ω_s, if the velocities of operation are also different and compensatory. To avoid this difficulty, a factor dependent only on performance data, and relating in simple form the characteristic index with the operational speed has been derived. This factor ω_r, which is called the speed ratio,* is given by the defined relationship,

$$\omega_r = \frac{\omega}{\omega_s} \qquad \text{(52)}$$

In *Fig.* 15, the lines representing ω_r = constant are inclined, like those for ω_s = constant, at a slope of 2/3. If the value of ω_r, corresponding to a point q, H is determined from the chart and rotational operating speed ω is known, the specific speed is given by $\omega_s = \omega/\omega_r$. Thus, with the addition of the family of lines for ω_r = constant, this chart can also be used as nomogram for determining ω_s. Similarly, the operational speed of a pump of known ω_s, q, and H is given by $\omega = \omega_r\omega_s$. In adopting the factor ω_r from Equation 52 instead of its reciprocal form, which may perhaps appear more logical, decimal values are avoided in the upper left-hand area of the chart—the area of most frequent use.

Basic Pump Series Types: In the preceding dis-

---

*P. Tedeschi—"Studio Grafico del Campo di applicazione di una Turbina Idraulica" *L'Industria,* Milan, Italy, 1925.

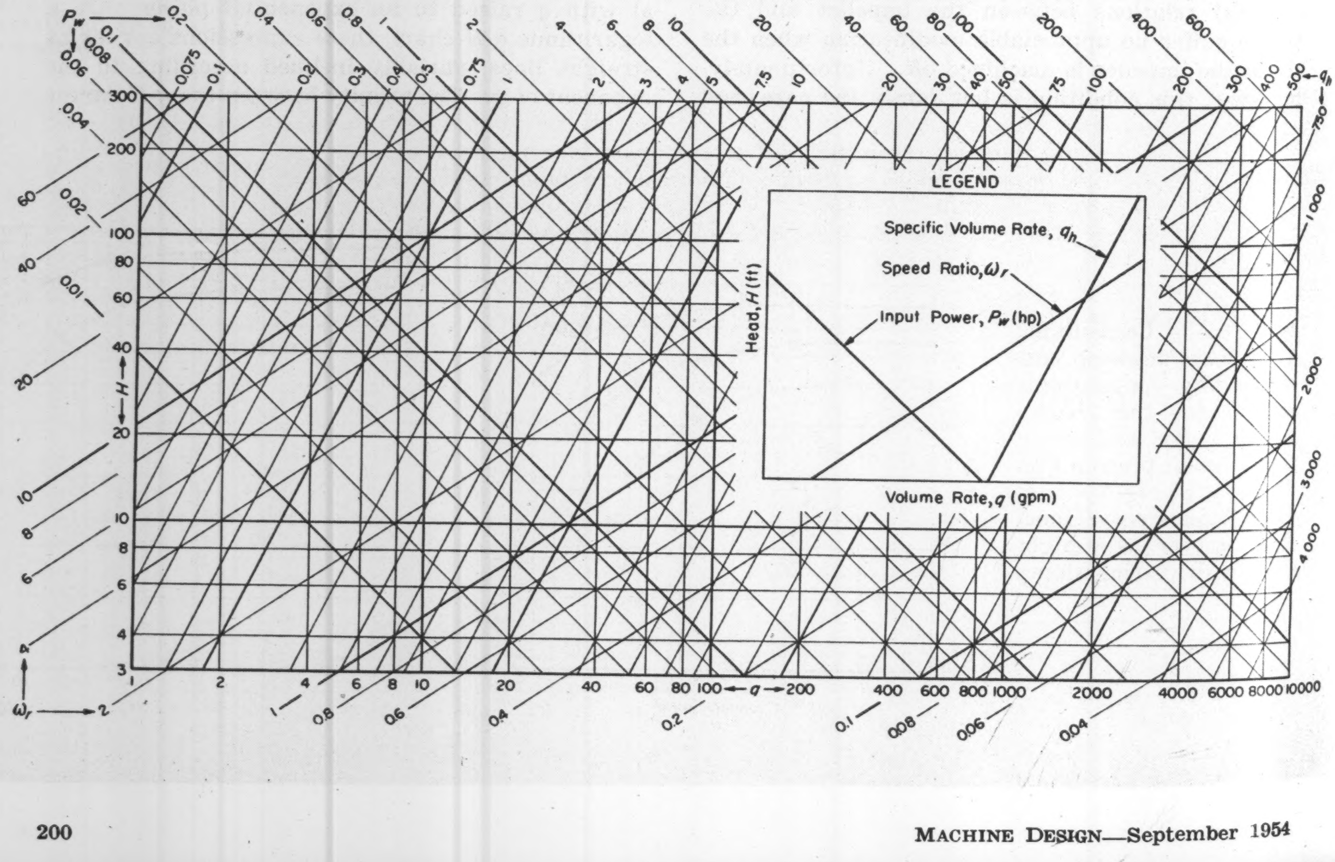


Fig. 15—Comprehensive logarithmic q-H chart for analysis of turbomachine series. The additional families of grid lines include plots of constant specific volume rate, constant power output and speed ratio

cussions on the development of similarity laws, reference has been made to some of the series that may govern the grouping of turbomachines. It will perhaps be helpful to define briefly these series types and list some of their important properties.

HOMOTHETIC SERIES: This type of series grouping is made up of geometrically similar machines having the same specific speed. If the individual machines of the series family operate at constant angular speed, their normal points are located on the logarithmic chart of *Fig.* 15 along a line for which ω_r = constant.

ISOBARIC SERIES: In this series, the machines produce uniform pressure under normal operating conditions. If the head coefficient is also the same for all of the machines, impeller tip speed becomes uniform and the series is called isodromic. On the Cartesian, as well as on the logarithmic chart, normal points for the elements of this type of series are located on the same constant pressure line.

ISODROMIC* SERIES: Constant tip speed is the identifying characteristic of this type of series. If the head coefficients of the individual machine units are uniform as in the case of homothetic machines, the series is also isobaric.

ISOTAKIC* SERIES: Machine elements of this type of series operate with equal angular velocity. This

---

*Since no special expression exists for distinguishing angular from lineal velocities, the convention adopted in these articles will be the Greek root "takis" for reference to rotational speeds and the root "dromas" for lineal velocities.

Table 9—Unitary Efficiency Curve Data for Impeller Pumps

Impeller Type	$q_u < 1$						$q_u > 1$					
	$q_{u,0.9}$			e			$q_{u,0.9}$			e		
	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean
Pure Radial	0.75	0.65	0.70	2.2	1.8	2.0	1.4	1.2	1.3	2.2	1.8	2.0
Mixed Flow	0.80	0.75	0.775	2.2	1.8	2.0	1.3	1.2	1.25	2.2	1.8	2.0
Pure Axial	0.85	0.80	0.825	2.0	1.5	1.75	1.2	1.1	1.15	2.5	2.0	2.25

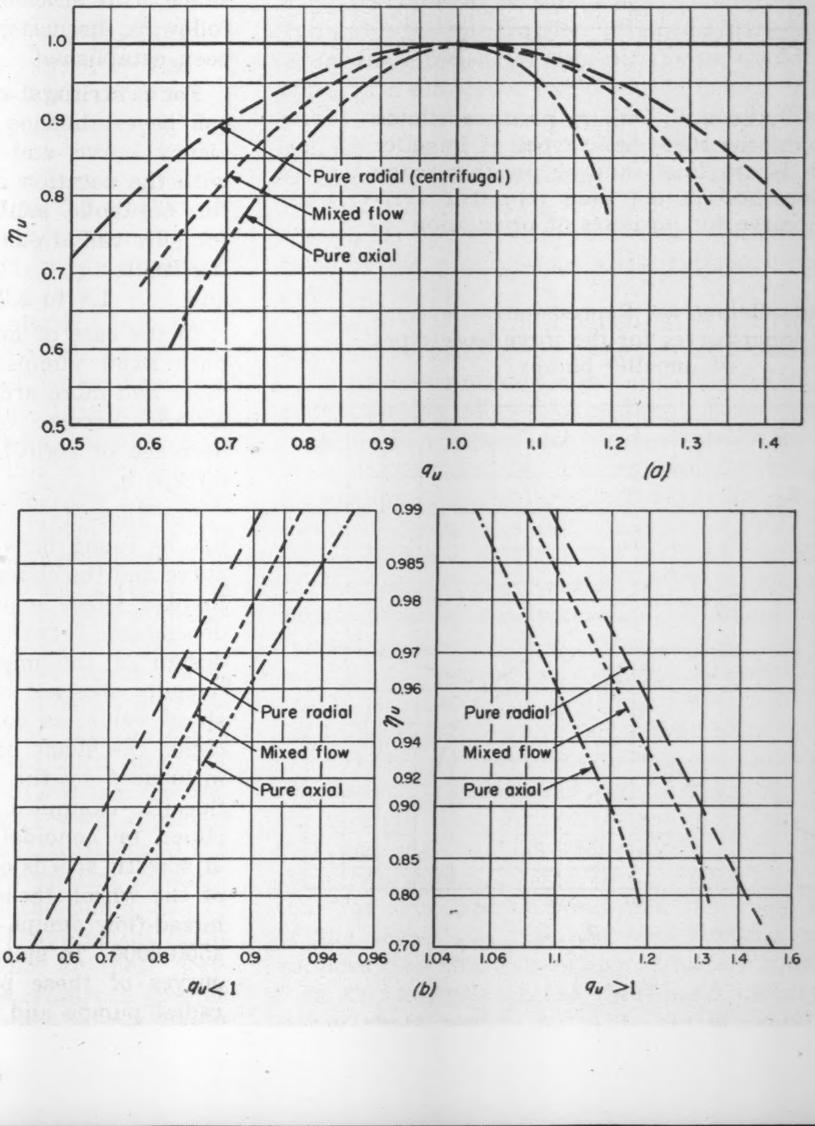


Fig. 16—Representative unitary efficiency curves, plotted on Cartesian co-ordinates at *a* and in logarithmic form at *b*, for the three basic types of hydraulic impeller pumps. Curve plots are based on mean data in *Table* 9

case fits pumps and fans directly driven by electric motors.

Isovolumetric Series: Elements of this series deliver the same volume flow rate, while working pressure varies from one unit to the other. These series are automatically obtained with multistage turbomachines, axial or radial, by varying the number of coupled stages.

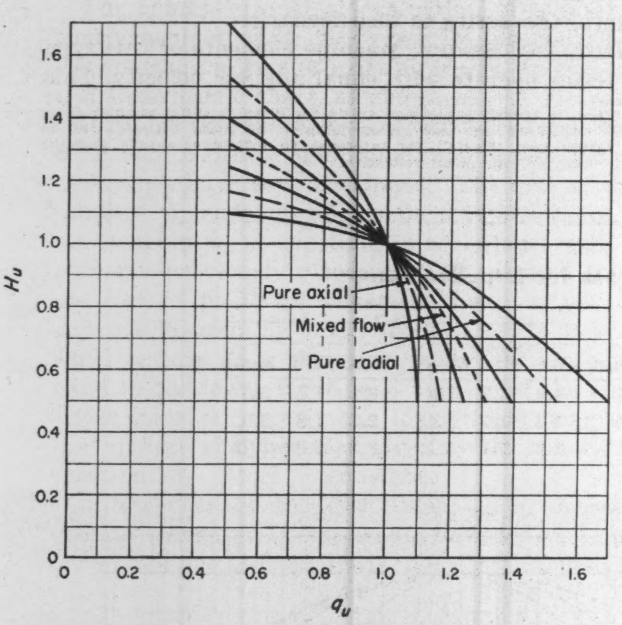
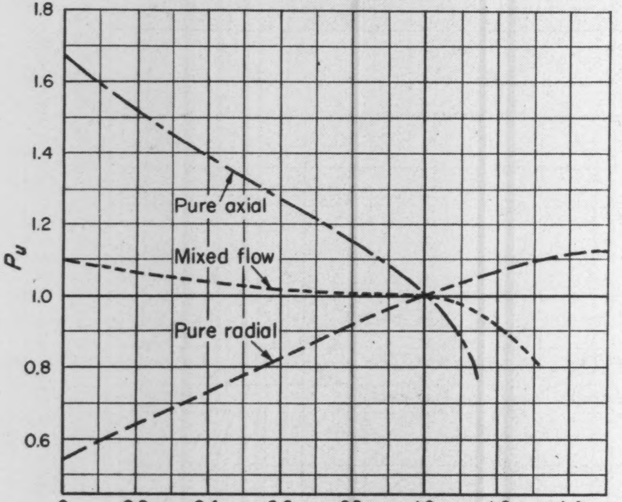


Fig. 17—Above — Unitary pressure-volume curves for the three basic types of impeller pumps. Heavy lines indicate possible range of values and dotted lines represent average curve for purposes of orientation

Fig. 18—Below — Representative unitary power input curves for the three basic types of impeller pumps



In the strictest sense, only the first and the last of these groups constitute what can be considered as a series; it is only in these two groups that the operational characteristics depend on design. For the others, operating characteristics depend on both design and the particular working conditions under which the machine operates.

Pump Performance Curves: The application range of a pump is generally limited by the shape of its efficiency curve, except in those special cases where other criteria must prevail. In series planning, care must be taken to prevent operation of any of the pump units at an efficiency too far under the normal or design value. Based on the author's experience, suitable criteria which lead to economically convenient series are, in terms of permissible efficiency loss, 10 to 12 per cent (unitary efficiency $\eta_u = 0.90 - 0.88$) in small pumps, about 5 per cent ($\eta_u = 0.95$) in the medium size units and about 2 per cent ($\eta_u = 0.98$) in large pumps.

Practical application of these criteria requires a knowledge of the shape of the efficiency curve for the specific type of pump. From an analysis of the efficiency curves for pumps of different type and origin, carried out in accordance with the criteria and graphical methods developed in *Part* 1, the relations between each type of pump and the shape of its efficiency curve have been studied. The following discussion highlights the facts that have been established.

For centrifugal or radial pumps no relationship can be established between the shape of the efficiency curve and specific speed. In accordance with the notation convention established in *Part* 1 for parabolic analysis, the equivalent parabolas for pure radial pumps oscillate between the following limits: $q_{u,\,0.9} =$ (0.65 to 0.75)-(1.20 to 1.40) and $e = 1.8$ to 2.2.

In the case of mixed-flow and especially for the pure axial pumps, the efficiency curves become more and more arched in their top point as shown by the increase of the left-hand value and the decrease of right-hand value of the reference intercept $q_{u,\,0.9}$.

For these types, too, a clear relationship could not be found between the shape of the efficiency curve and the characteristic index of specific speed. Instead, there is pronounced evidence of an interdependence between the shape of the curve and the design of the impeller. When the shape of the impeller does not exactly correspond to the specific speed value, as sometimes happens in special designs, the shape of the efficiency curve is usually influenced by the first factor and not the latter. Specific examples are deep well pumps with inclined or conoidal flow impellers which operate at specific speeds of 2300-2900. Based on the shape of the wheel, these designs belong to the class of mixed-flow pumps having characteristic indexes of 4500-6000. In spite this peculiarity, the efficiency curves of these pumps resemble those of axial-radial pumps and not those corresponding to the pure radial types.

In *Table* 9, representative unitary efficiency curve data for the three principal pump types have been summarized. Curve plots of the mean data, in both Cartesian and logarithmic forms, appear in *Fig.* 16. As shown in the chart of *Fig. 16b,* the efficiency curves of radial-axial and axial pumps deviate from parabolic form in the overload zone. On the other hand, these pumps can not be used in that zone because of the rapid pressure drop that takes place there.

Unitary pressure-volume curves of the three principal types of pumps are shown in *Fig.* 17. It can be seen that the slopes of the curves gradually increase in going from the radial to the axial type until, in the case of the latter, the slope is such that the application range of the machine is limited for lack of pressure rather than for decrease of efficiency, as indicated in the foregoing discussion.

Table 10—Typical Series Planning Data for Impeller Pumps

Pump Type	Unit Size	$q_u<1$ η_u	$q_u<1$ q_u'	$q_u>1$ η_u	$q_u>1$ H_u	$q_u>1$ q_u''	Series Ratio
Pure Radial	Small	0.88	0.67	0.88	0.73	1.33	**1.98**
	Medium	0.95	0.79	0.95	0.84	1.215	**1.54**
	Large	0.98	0.865	0.98	0.91	1.135	**1.31**
Mixed Flow	Small	0.88	0.765	0.88	0.60	1.27	**1.68**
	Medium	0.95	0.84	0.95	0.79	1.175	**1.40**
	Large	0.98	0.90	0.98	0.90	1.11	**1.23**
Pure Axial	Small	0.88	0.805	0.88	0.58	1.16	**1.44**
	Medium	0.95	0.88	0.95	0.77	1.11	**1.26**
	Large	0.98	0.93	0.98	0.80	1.073	**1.15**

The pressure chart has been divided into three regions, corresponding to centrifugal, mixed-flow and axial pumps, and a dotted curve has been drawn in the middle of each zone. This curve may be considered as typical of the particular type of pump for purposes of orientation, a function for which the actual curve is not generally available. But once the analysis of a basic model has established the true curve, it is more convenient to take this actual result as a basis for tracing the pump line since the curves of *Fig.* 17 give only approximate mean values

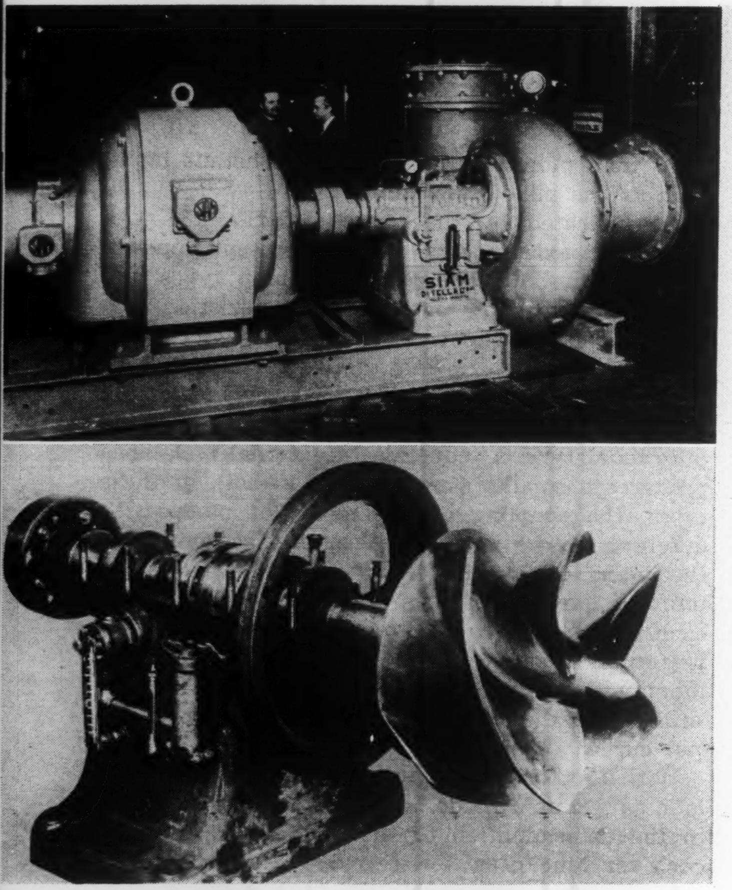
The shape of the unitary power input curve, *Fig.* 18, has no direct influence on series development in its initial phase. It must only be taken into account when, during the detailed study of a line of pumps directly driven by electric motors, the number of power connections with standard motors for each pump has to be calculated and the safety ratio, to be allowed between the capacity of each motor and the input of the pump, has to be fixed. It is evident that the shape of the input power curve has a direct influence on these decisions; pumps with sloped curves require a greater number of power connections and a larger safety ratio than pumps with an almost constant input, such as the mixed-flow units.

As indicated by the curves in *Fig.* 18, pure radial and axial pumps, which represent opposite extremes in both the range of pump types and specific speed, show opposite characteristics with regard to power input. For the former, as power increases with volume rate the danger of overloading the motor increases when the resistance of the external circuit decreases. Conversely, for the pure axial type, a reduction of external resistance produces a smaller power input. In both of these cases, the coupling of one model of pump with different motors must be taken into account. For the intermediate mixed-flow units, however, the uniform power characteristics generally permit each model to be coupled with a single motor size, preferably the one that is best suited to the maximum power input indicated by the maximum ordinate on the plot of the corresponding power input curve.

With the foregoing considerations of characteristic curves as a guide, attention can now be given to the determination of the application range of each machine of a series and, consequently, the ratios of the progression of operational modules. From the effeciency curve for the particular pump type, with allowance for loss of efficiency based on power requirements, the two limiting values of volume rate for the application range can be established, the minimum value acting as the limit in the region $q_u < 1$ and the maximum in the region $q_u > 1$. As previously pointed out, the ratio of the progression is the ratio of these two limiting values.

Results of a typical calculation to determine application ranges for the three principal pump types in the whole range of sizes are collected in *Table* 10. Minimum allowable unitary efficiencies have been fixed in accordance with criteria cited previously in this article. Unitary volume rates corresponding to each unitary efficiency have been determined from parabolic analysis of typical efficiency curves, *Fig.* 16*b*. The series ratios given in the far right-hand column of *Table* 10 are the ratios between maximum and minimum unitary volume rates, q_u'' and q_u', respectively. Calculation of this ratio can perhaps be best demonstrated by taking as an example the small centrifugal pumps for which data are given in the top line of *Table* 10. On *Fig.* 16*b* at the ordinate value $\eta_u = 0.88$, the abscissas of the left and right-hand intercepts of the straight lines for centrifugal pumps are $q_u' = 0.67$ and $q_u'' = 1.33$, respectively. The ratio of these two values is $1.33/0.67 = 1.98$, which means that for this type of pump and the given region of the series the ratio between limiting normal volumes may be taken as approximately equal to 2.

In the analysis of the right-hand unitary efficiency chart region, $q_u > 1$, the pressure value



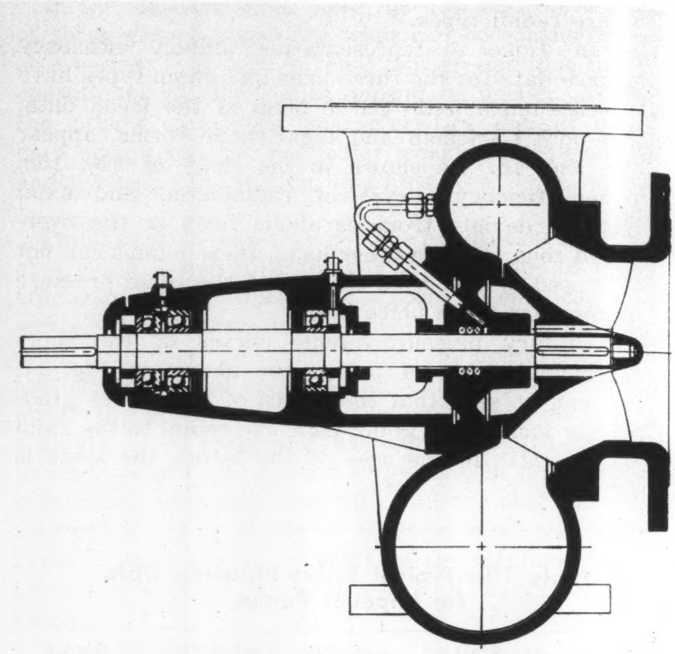


Fig. 19—Typical mixed-flow pump designs showing cross section of small-size unit and two views of similar medium-size unit. Photos, courtesy Siam-Di Tella Ltda., Buenos Aires

corresponding to the limiting maximum volume and determined on the basis of efficiency criterion, has been taken into account. This supplementary investigation has been made to assure that the calculated maximum volume does not fall to the right of the "breakdown" zone of the pressure curve, a case which would render adoption of that value impossible.

That the latter undesirable condition does not occur for the pump groups in *Table* 10 is indicated by the values of unitary head, H_u. Thus, it must be generally concluded that when pressure drops rapidly on the overload side of the normal point, efficiency also acts in the same manner and volume rate is limited at nearly the same time by both of these restricting influences. Nevertheless, the importance of the pressure-maximum volume relationships must not be overlooked, since there are pumps in which the pressure drop acts to limit the volume rate before the point of smallest allowable efficiency is reached.

The following example will perhaps be helpful in demonstrating how the data of *Table* 10 may be directly applied to the planning of a series.

Centrifugal Pump Series: Assume that a series of centrifugal pumps (top group of *Table* 10) is to be planned in which the ratio between the limiting operational modules is approximately 1/150. To determine the required series, it will be necessary to find a second-order progression covering the range of term values and having first and last ratios equal to those given in *Table* 10 for the small and large size pure radial pumps, respectively, 1.98 and 1.31.

From the planned progressions listed in *Table* 5 of *Part* 2, if the last term of progression 6-13-A is disregarded and the remaining terms are raised to the third power, the following series is obtained: Number of terms, $n = 12$; first term, $a = 1$; last term, $l = 5.31^3 = 149.7 \approx 150$; first ratio, $r = 1.259^3 = 1.995 \approx 2.00$; last ratio, $r_n = 1.076^3 \approx 1.246 \approx 1.25$.

These values agree closely with the given data and if deviations occur they are in a favorable sense. Operational modules will thus also be proportional to the cubes of the terms of the planned progression, forming the series: 1.00, 2.00, 3.80, 6.86, 12.00, 19.68, 31.26, 46.66, 67.42, 91.73, 119.8, 149.7.

Mixed-Flow Pump Series: The following example illustrates the development of a complete pump line.

Assume that a line of mixed-flow pumps having a basic design similar to that shown in *Fig.* 19 is to be traced. The operational characteristics of the pumps composing the series are based on complete tests perfomed with a model unit, which has the following characteristics: Nominal diameter (measured at the center point of the development of the outlet edge of the impeller vane), $D = 10$ in.; impeller angular velocity, $\omega = 1430$ rpm; impeller design tip speed, $v_n = 62.4$ fps;

total manometric head, $H_n = 37.95$ ft; volume flow rate, $q_n = 3640$ gpm; efficiency, $\eta = 84$ per cent; input power, $P = 41.5$ hp; volume coefficient, $\phi = 0.187$; head coefficient, $\psi = 0.627$; specific speed, $\omega_s = 5{,}640$.

Based on the reasons given previously in the description of the different types of pump series, it can be shown that this case is typical of one in which a homothetic line must be followed. The series must also be isobaric because the proposed application of these pumps requires a uniform pressure output oscillating around the value at which the model pump has been tested; that is, between 35 and 40 ft. Both types of series may be integrated under the condition that each pump operate at a different rpm, as determined by isodromic considerations.

Limiting volume rates to be assigned to the series, as determined on the basis of the most probable market requirements, are: Minimum volume rate = 1500 gpm, maximum volume rate = 24,000 gpm. The ratio between these limiting values is 24,000/1500 = 16 approximately.

For a first approach, it will be assumed that the efficiency of all of the units of the series remains constant and equal to that of the model pump. Normal input power is thus 250 and 18 hp for the largest and smallest pumps, respectively, both values being calculated from the limiting volume rates on the basis of a constant head of 37.95 feet. With these power values, which are factors of considerable importance for centrifugal pumps, the allowable losses in efficiency must be relatively low. For the smallest and largest elements of the series to be traced, permissible losses of 10 and 5 per cent, respectively, will be taken.

Minimum allowable unitary efficiencies are thus, $\eta_u = 0.90$ and $\eta_u = 0.95$. With these efficiency values as a basis, the limiting volume rates corresponding to the smallest and largest pump units may be found through parabolic analysis of the model pump efficiency curve on a symmetrical double-sided logarithmic chart of the type shown in *Fig.* 5 of *Part* 1. Initial and final ratios of the progression of volume rates are then derived from the calculated ratios of the limiting volume rates determined for each unitary efficiency value. The

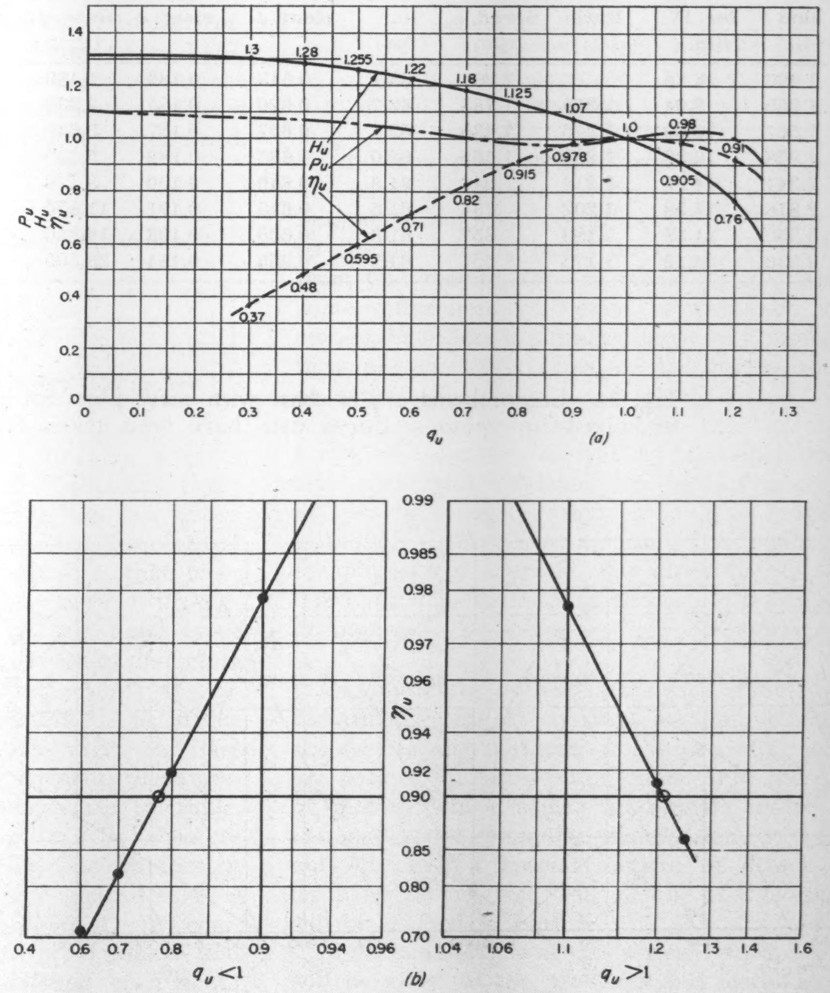


Fig. 20—Graphical analysis of mixed-flow pump test model characteristics showing: *a*, unitary performance curves and *b*, logarithmic plot of unitary efficiency curve

following analysis may be helpful in illustrating the details of this procedure.

Curves of unitary efficiency, power input and head for the model pump, as plotted from test data, are shown in *Fig. 20a*. Specific point values have been indicated for convenience of identification. Significant points on the efficiency curve for purposes of parabolic analysis are:

q_u	η_u	q_u	η_u
0.7	0.82	1.1	0.978
0.8	0.915	1.2	0.91
0.9	0.978	1.25	0.86
1.0	1.0		

Curve plots of these points on a double-sided logarithmic chart, in which the goniometric scales have been omitted, are shown in *Fig. 20b*. Reference values for these curves, using the notation discussed in *Part* 1, are found from the chart to be: $q_{u,\,0.9} = 0.78\text{-}1.21$, $e = 2\text{-}2$. The complete results of the curve analysis are as follows:

Allowable Efficiency Loss (per cent)	η_u	q_u''	q_u'	q_u''/q_u'
10	0.90	1.21	0.78	1.21/0.78 =1.55
5	0.95	1.16	0.845	1.16/0.845=1.38

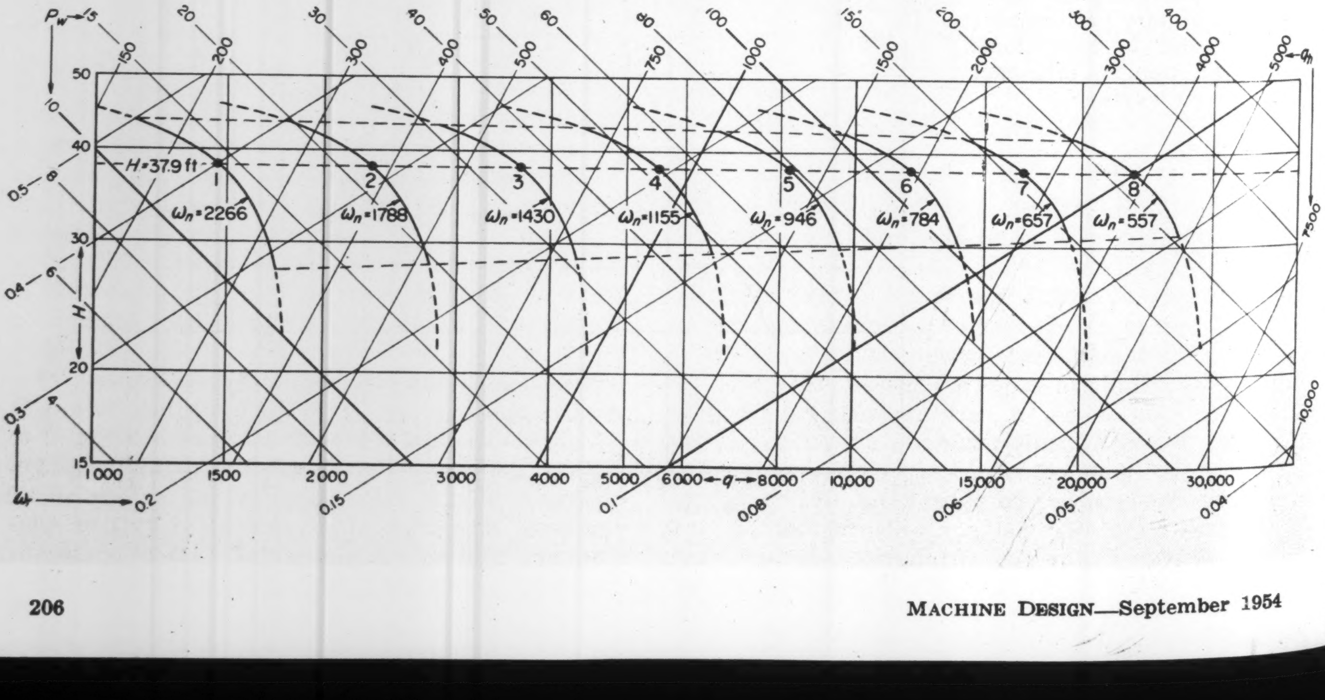
In summary, two important conditions relating to the series of operation modules have now been established: (1) The ratio of the values of the limiting terms of the series of volume rates must be approximately equal to 16 and (2) the first and last ratios of the corresponding progression must be 1.55 and 1.38, respectively. Attention may now be directed to evaluation of the analogous characteristics of the series of geometrical modules.

From the laws of similarity, it has been established that the geometrical modules of a homothetic isobaric series (reference diameters) are proportional to the square root of the operational modules (normal volumes). Consequently, according to the properties of second-order progressions,

Table 11—Mixed Flow Pump Series

Series Model	Series Progression	Impeller Diameter, D (in.)	Diameter Ratio	Rotational Speed, ω_n (rpm)	Tip Velocity, v_n (fps)	Head Coefficient, ψ	Volume Coefficient, ϕ	Volume Rate, q_n (gpm)	Volume Rate Ratio	Head, H (ft)	Efficiency, η_n (per cent)	Power Input, P_n (hp)
1	1.000	6.38	....	2.266	63.1	0.613	0.182	1,460	....	37.9	82.0	17.1
2	1.259	8.04	1.259	1.788	62.7	0.620	0.185	2,330	1.601	37.9	83.0	27.0
3	1.567	10.00	1.245	1.430	62.4	0.627	0.187	3,640	1.558	37.9	84.0	41.5
4	1.928	12.30	1.230	1.155	62.0	0.635	0.189	5,530	1.520	37.9	84.8	62.4
5	2.344	14.96	1.216	946	61.8	0.640	0.190	8,170	1.477	37.9	85.6	91.4
6	2.818	17.98	1.202	784	61.5	0.645	0.191	11,850	1.451	37.9	86.2	132.0
7	3.350	21.38	1.189	657	61.3	0.650	0.193	16,850	1.422	37.9	86.8	186.0
8	3.936	25.12	1.175	557	61.1	0.655	0.194	23,300	1.383	37.9	87.4	256.0

Fig. 21—Comprehensive *q-H* chart with curve plots for planned series of mixed-flow pumps. Curve data have been taken from *Table* 10



the ratio between the values of the limiting terms of the series will be $\sqrt{16} = 4$, while the first and last ratios of the same series will be $\sqrt{1.55} \approx 1.25$ and $\sqrt{1.38} \approx 1.18$, respectively. These data would be sufficient to permit calculation of a series, but it is convenient to try first for direct adoption of one of the planned second-order progressions, *Table* 5, seeking in particular one having an element corresponding to the model pump on which the series development has been based.

None of the planned progressions fit the requirements exactly; however, a sufficiently close approach is obtained if the 10-17-A series is limited to the first eight terms. This modified grouping gives a term ratio of 3.936 and limiting progression ratios of 1.259 and 1.175 as compared to the desired results of 4, 1.25 and 1.18.

At this stage in the series development, it is convenient to make sure that the series is in accord with the economical criterion given in *Part* 1. If the line is extended until the ratio of limiting terms reaches 10, the number of terms becomes 17. This number falls in the range of maximum convenience established by economic considerations, and is on the high side of this range as required by the commercial criteria. The series is thus acceptable from three points of view: efficiency, production cost and sales.

From Equation 31, solving for D and assuming for this first approach that ϕ and v_n along the entire line remain constant and equal to the corresponding values for the model pump ($\phi = 0.187$, $v_n = 62.4$ fps) gives the reference diameters of the smallest and largest types. Calculations are based on the limiting volume rates previously determined. Thus, for $q = 1500$ gpm $= 3.45$ cfs,

$$D = \sqrt{\frac{3.45}{0.187(62.4)}} = 0.54 \text{ feet} = 6.5 \text{ inches}$$

and for $q = 24{,}000$ gpm $= 53.5$ cfs,

$$D = \sqrt{\frac{53.5}{0.187(62.4)}} = 2.14 \text{ feet} = 25.7 \text{ inches}$$

The complete development of this line is given in *Table* 11. Incorporation of the model pump as one of the units of the final line has necessitated a correction in the reference diameters of the first and last models. In effect, if that basic reference diameter (10.00 inches) is made to correspond to the third term of the fixed basic progression 10-17-A, and all the other diameters are made proportional to the remaining progression terms, the reference diameters listed in the table are obtained. Although the first and last of these values are not exactly equal to those previously determined, the differences are tolerable.

To account for the influence of the absolute size of each model on its actual performance, a possible and probable scale of the quantities ψ, ϕ and η has been developed in *Table* 11 by comparison of the present case with other known and similar cases. From the established coefficients of ψ and based on a constant head, H_n, for the whole line, the peripheral speed v_n for each unit can be calculated from Equation 32. It will be noted that this is the first departure from the ideal isodromic series concept and is necessitated by the fact that the manometric head coefficient ψ varies slightly along the line, thus deviating from the ideal case.

From the established values of velocity, v_n, basic diameter, D, and the probable scale of volumetric coefficients ϕ, the normal flow rates of each model, q_n, can be determined by means of Equation 31. Rotational speeds, ω_n, can be found directly from v_n and D.

Power input, P_n, for each unit can be readily determined from the values of volume rate, q_n, constant head, H_n, and probable efficiency, η_n. The efficiency values constitute the third probable scale of factors that must be predicted on the basis of similar known cases.

As a final check on the series planning results, the actual volume rates and their ratios must be compared with the values initially established for the limiting flow rates and the limiting ratios of the series of volumes rates. This comparison is as follows:

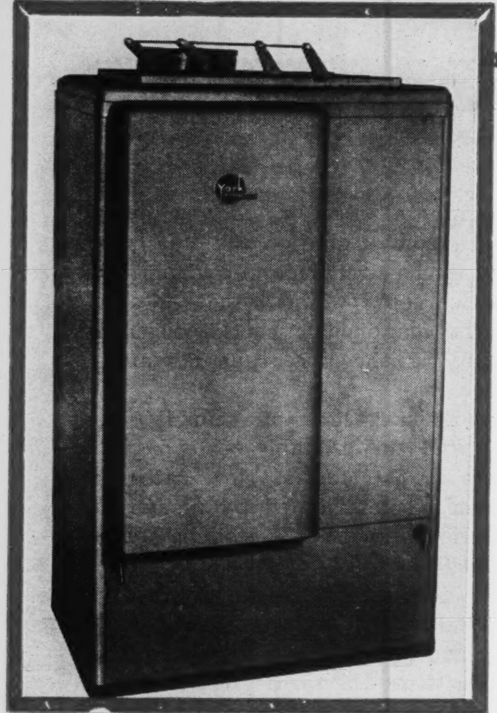
	Volume Rates	Limiting Ratios
Desired	1500-24,000	1.55-1.38
Actual	1460-23,000	1.601-1.383

The curve plots of this series on a *q-H* logarithmic chart are shown in *Fig*. 21. The *q-H* curves passing through the design points have been traced as similar curves, based on the curve, developed from test results, for the model pump. Actually, some differences will exist between the various curves, but these differences have only a secondary influence on the tracing of the series and may be neglected.

It must be emphasized that this example of series development, as well as the other practical and numerical examples to be given in these articles, can not be assumed to have general applicability. Differences in production facilities and techniques, for example, may often dictate a modified approach to the application of the same basic principles.

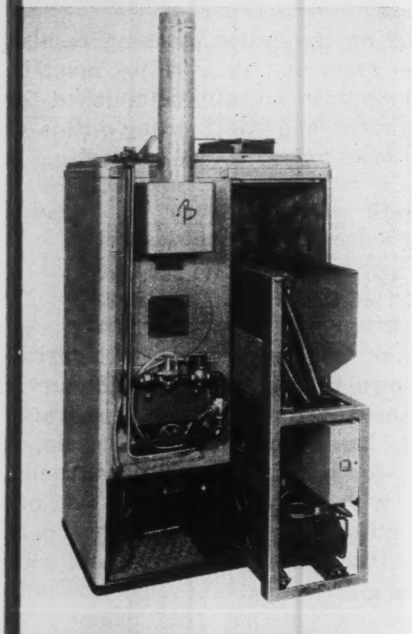
Isotakic Pump Series: In the case of direct-driven pumps operating at constant angular velocity, the procedures and methods of the preceding example are only of limited use and value. For these types of pumps, which utilize an electric motor drive, rational series planning results can be achieved only through a special method of attack based on different criteria. Full details of this approach will be treated in Part 5.

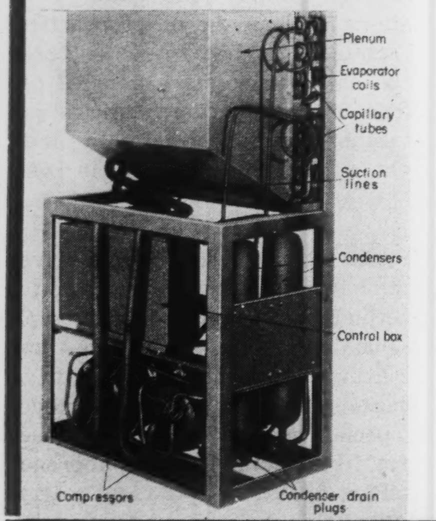
In the next article of this series, *Part* 4, attention will be given to the problems and methods of attack in planning series of gear reducers.



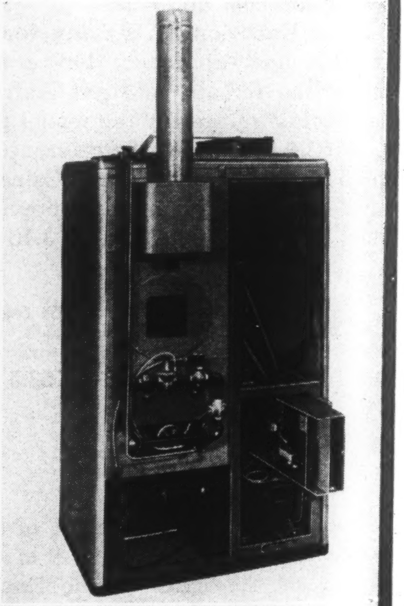
Air Conditioner-Furnace Designed for Serviceability

Compactness and design for serviceability are outstanding characteristics of a recently introduced furnace-air conditioner for residential use. Units now being built have nominal cooling capacities of 2.1 and 3.2 tons of refrigeration and heat outputs of approximately 80,000 and 112,000 Btu per hour. Designed to be used with conventional hot-air heating ductwork for both heating and cooling, the York Corp. Yorkaire heating unit may be fired by any kind of domestic heating oil or any type of fuel gas, such as natural, mixed, manufactured, liquefied petroleum or dual fuel gas. Smaller of the two units measures only 26½ by 36½ by 63 inches high and is priced below $1000.

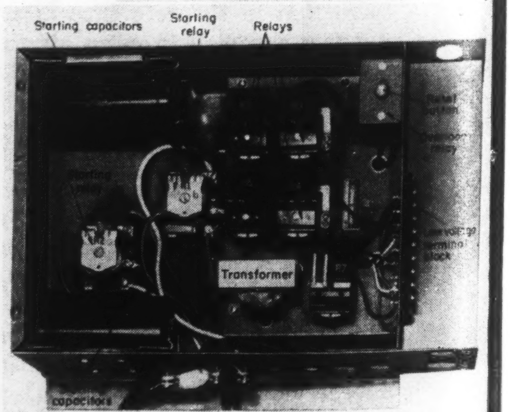



Plenum
Evaporator coils
Capillary tubes
Suction lines
Condensers
Control box
Compressors
Condenser drain plugs

Air conditioning unit of the Yorkaire consists of two separate cooling systems, each powered by a 1-horsepower electric motor in this 2.1 ton cooling capacity model. Servicing is facilitated by pull-out design which provides easy access for parts replacement or permits replacement of the entire unit by another, with no necessity of taking down ductwork. Twin cooling systems use step-starting to reduce starting current inrush which would exist if both motors were started simultaneously or if only a single motor of equal horsepower were used. Operating economy is also provided by automatic operation of only one cooling and dehumidifying circuit when full capacity is not required. When cooling or dehumidifying requirements exceed the capacity of one unit the other is automatically placed in operation.



Electrical control package of the cooling unit can be slid forward to allow easy access to the parts for servicing. Removal and replacement of the entire box as a unit is also possible. All motor starting relays and capacitors, overload relays, step starting relays, a circuit breaker and transformer are mounted in the removable control box.


Starting capacitors
Starting relay
Relays
Reset button
Overload relay
Starting relay
Low voltage terminal block
Transformer
capacitors

CONTEMPORARY DESIGN

MACHINE DESIGN
Data Sheet

CHARTS SIMPLIFY

Design of Positive-Displacement PUMPS AND MOTORS

. . . By Reiner J. Auman
Design Engineer
Kerns Mfg. Corp.
Long Island City, N. Y.

IN THE DESIGN of positive-displacement pumps and motors, the basic variable hydraulic features of fluid mechanics, such as viscosity and fluid inertia, generally play only subordinate rolls and can accordingly be frequently neglected. This leaves only geometrical construction as the major important criteria for similarity. As shown in a previous article,* volumetric capacities of gear pumps can be determined from known characteristics of other gear pumps. In general this same reasoning holds true for other types of constant-delivery pumps. Thus, from the familiar equation of volumetric capacity of a vane pump, *Fig.* 1,

$$Q = 0.0272\ Denw \qquad (1)$$

similarity considerations make it possible to write

$$\frac{Q_1}{Q_2} = \frac{D_1 e_1 n_1 w_1}{D_2 e_2 n_2 w_2} \qquad (2)$$

Likewise, by employing the equation of volumetric capacity of a piston type pump, *Fig.* 2,

$$Q = 0.008656\ AlNn \qquad (3)$$

it can be shown that

$$\frac{Q_1}{Q_2} = \frac{A_1 l_1 N_1 n_1}{A_2 l_2 N_2 n_2} \qquad (4)$$

Since, in initial design work, efficiency nearly always enters into the picture, it is important to know how a single unit will perform when used interchangeably as pump or motor—which is common practice. On the surface it would appear that a hydraulic unit should perform equally well when employed as either a pump or a motor, but this is not always true. Total efficiency for a hydraulic unit is

$$\eta_T = \eta_V \eta_M \qquad (5)$$

Volumetric efficiency for a pump is

$$\eta_{Vp} = \frac{Q_{op}}{Q_{dp}} = \frac{Q_{op}}{Q_{ip}} \qquad (6)$$

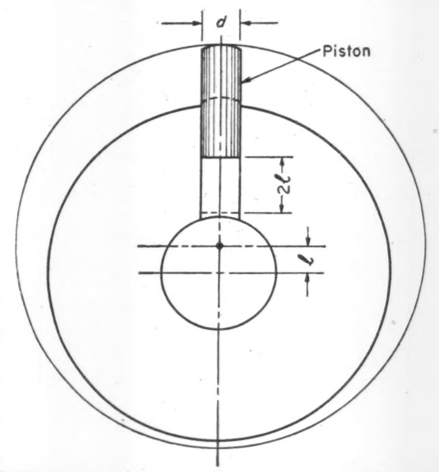


Fig. 1 — Left — Basic cross-sectional diagram of piston type pump

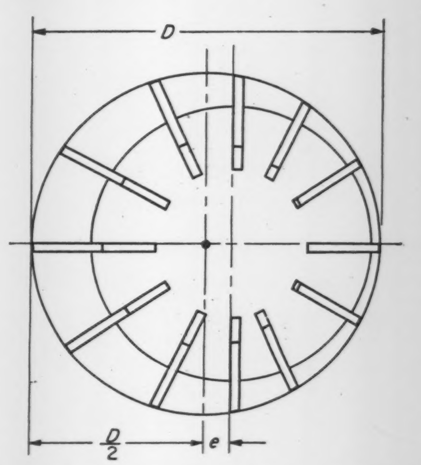


Fig. 2 — Right — Basic cross-sectional diagram of vane type pump

---

*Reiner J. Auman—"Chart Simplifies Design of Gear Pumps," MACHINE DESIGN, Vol. 26, No. 3, March 1954, Pages 185-187.

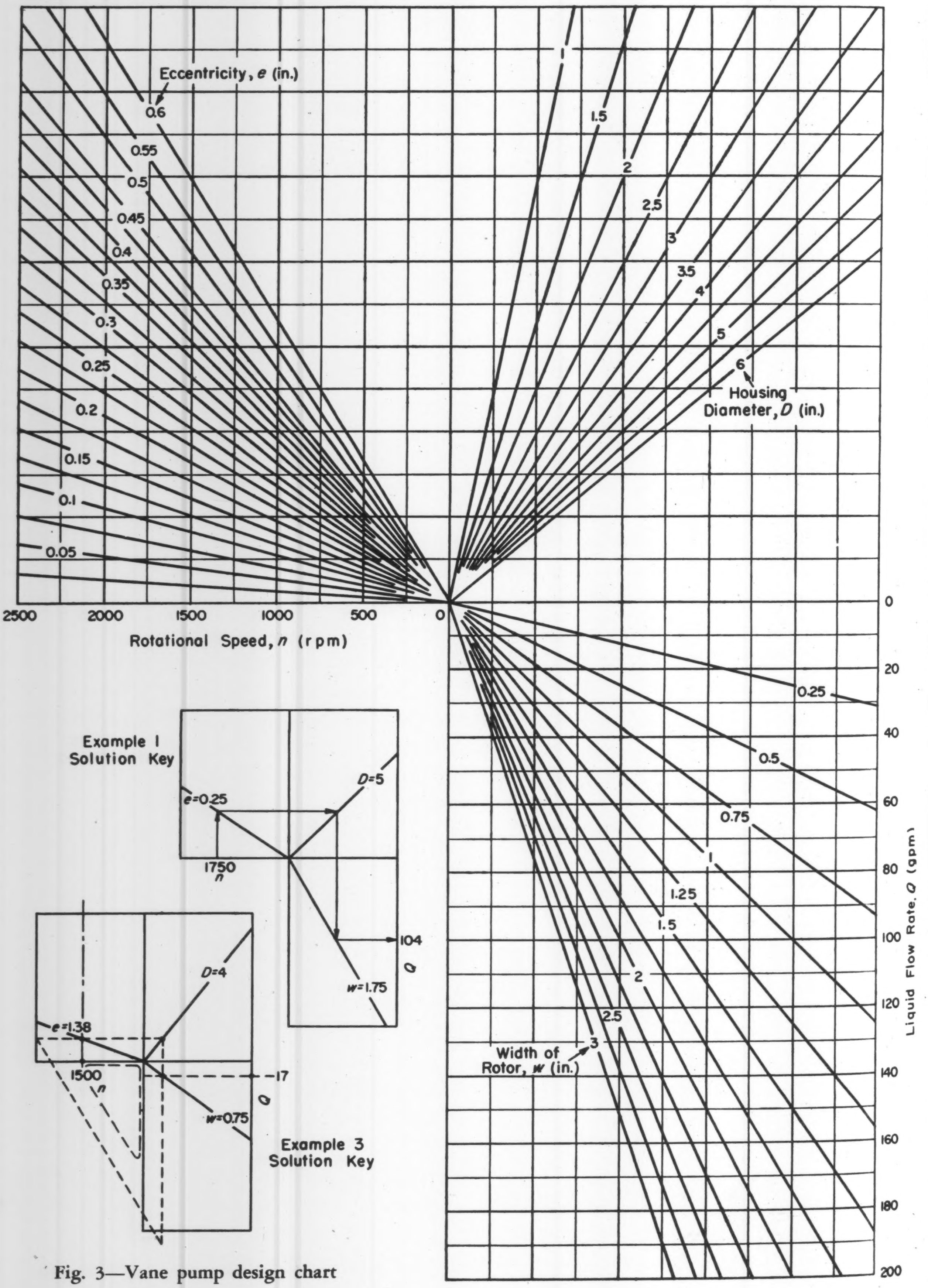


Fig. 3—Vane pump design chart

while the volumetric efficiency for the same hydraulic unit used as a motor is

$$\eta_{Vm} = \frac{Q_{dm}}{Q_{im}} = \frac{Q_{om}}{Q_{im}} \tag{7}$$

The mechanical efficiency of a pump may be expressed

$$\eta_{Mp} = \frac{P_{hp}}{P_{ip}} = \frac{P_{op}}{P_{ip}} \tag{8}$$

and for a motor the mechanical efficiency is

$$\eta_{Mm} = \frac{P_{om}}{P_{hm}} = \frac{P_{om}}{P_{im}} \tag{9}$$

Therefore, when a hydraulic unit is used as a pump, it can be shown that pump output power of the fluid discharged is

$$P_{op} = 0.000583\ Q_{op}\ p \tag{10}$$

Nomenclature

A = Area of piston in piston pump, sq in.
D = Diameter of vane pump housing, in.
d = Diameter of piston in piston pump, in.
e = Eccentricity distance in vane pump, in.
l = Length of stroke in piston pump, in.
N = Number of pistons in piston pump
n = Rotational speed, rpm
P_h = Hydraulic power, hp
P_i = Input power, hp
P_o = Output power, hp
p = Hydraulic pressure, psi
Q = Hydraulic flow rate, gpm
Q_d = Geometric displacement flow rate, gpm
Q_i = Input flow rate, gpm
Q_o = Output flow rate, gpm
η_M = Mechanical efficiency of hydraulic unit, per cent
η_T = Total efficiency of hydraulic unit, per cent
η_V = Volumetric efficiency of hydraulic unit, per cent
w = Width of vane pump rotor, in.
Subscripts: m denotes motor, p denotes pump

By transposing terms in Equation 6, pump output flow rate is $Q_{op} = \eta_{Vp}\ Q_{dp}$ which substituted in Equation 10 shows pump output power can be expressed

$$P_{op} = 0.000583\ Q_{dp}\ \eta_{Vp}\ p \tag{11}$$

Likewise, hydraulic power input to a unit used as a motor can be expressed

$$P_{hm} = 0.000583\ Q_{dm}\ p \tag{12}$$

Since the output of a motor is by nature mechanical, by transposing terms in Equation 9 the motor hydraulic power $P_{hm} = P_{om}/\eta_{Mm}$ which substituted in Equation 12 gives

$$P_{om} = 0.000583\ Q_{dm}\ \eta_{Mm}\ p \tag{13}$$

Dividing Equation 13 by Equation 11 results in the following fundamental power and efficiency relationship

$$\frac{P_{om}}{P_{op}} = \frac{\eta_{Mm}}{\eta_{Vp}} \tag{14}$$

since $Q_{dp} = Q_{dm}$ in the same hydraulic unit and these terms cancel. Thus, when the mechanical and volumetric efficiencies are equal, a unit will perform equally well as either a pump or a motor. If, however, the mechanical efficiency is higher, performance of the unit as a motor will be better. If volumetric efficiency is higher, the unit will operate more efficiently as a pump.

Chart Solutions: Pump or motor geometrical dimensions may be rapidly determined by employing the charts shown in ***Figs.*** 3 and 4. The chart in ***Fig.*** 3 is for vane type units and ***Fig.*** 4 is for piston type units. The alignment chart in ***Fig.*** 5 enables the designer to quickly determine power, pressure, and rate of flow in conjunction with the charts in ***Figs.*** 3 and 4.

The following example problems and solutions illustrate the general use of the charts. The first example shows the solution procedure for determining flow rate from a vane pump.

EXAMPLE 1. Determine output flow rate of a vane pump in which rotor width $w = 1.75$ inches, eccentricity $e = 0.25$-inch, housing diameter $D = 5$ inches and rotational speed $n = 1750$ rpm.

Start from the $n = 1750$-rpm point on the rotational speed scale in the ***Fig.*** 3 chart and rise vertically until the $e = 0.25$-inch line is intersected. From this intersection go horizontally right until the $D = 5$-inch line is crossed, then drop vertically to the $w = 1.75$-inch line. At this intersection go horizontally right until the flow-rate scale is intersected and read $Q = 104$ gpm, approximately.

EXAMPLE 2. As an illustration of how to handle the factors of efficiency and power, suppose a piston pump is to be designed which will have an output flow $Q = 65$ gpm when driven at a rotational speed $n = 1800$ rpm against a pressure $p = 500$ psi. Assuming a volumetric efficiency $\eta_V = 95$ per cent and a mechanical efficiency $\eta_M = 85$ per cent, find suitable pump dimensions and pump input power required.

Design output flow rate is found by dividing actual required output flow rate by volumetric efficiency or $65/0.95 = 68.4$ gpm. On *Fig.* 4, lay off a line horizontally left from the point $Q = 68.4$ gpm and cut across all the number of pistons

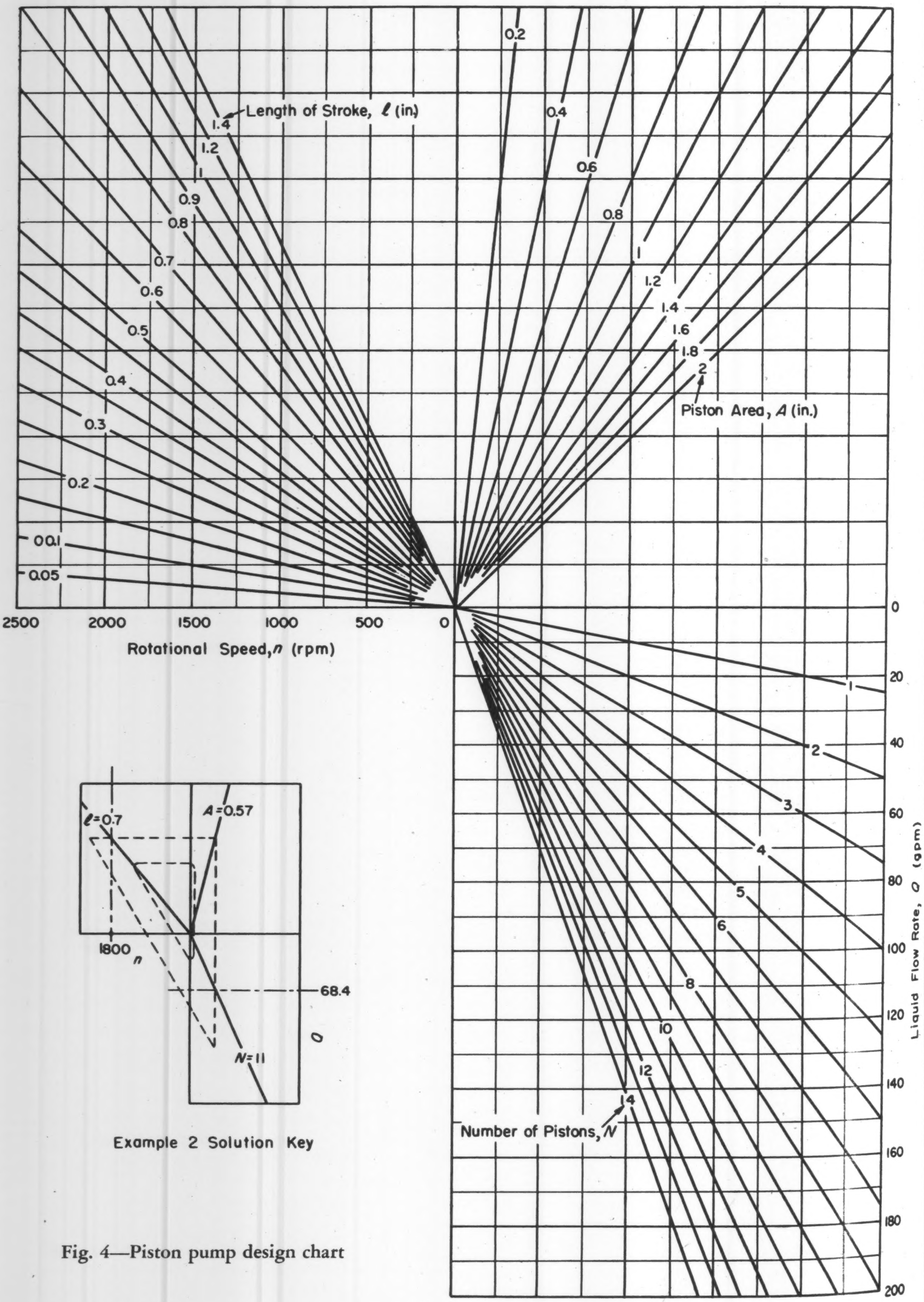


Fig. 4—Piston pump design chart

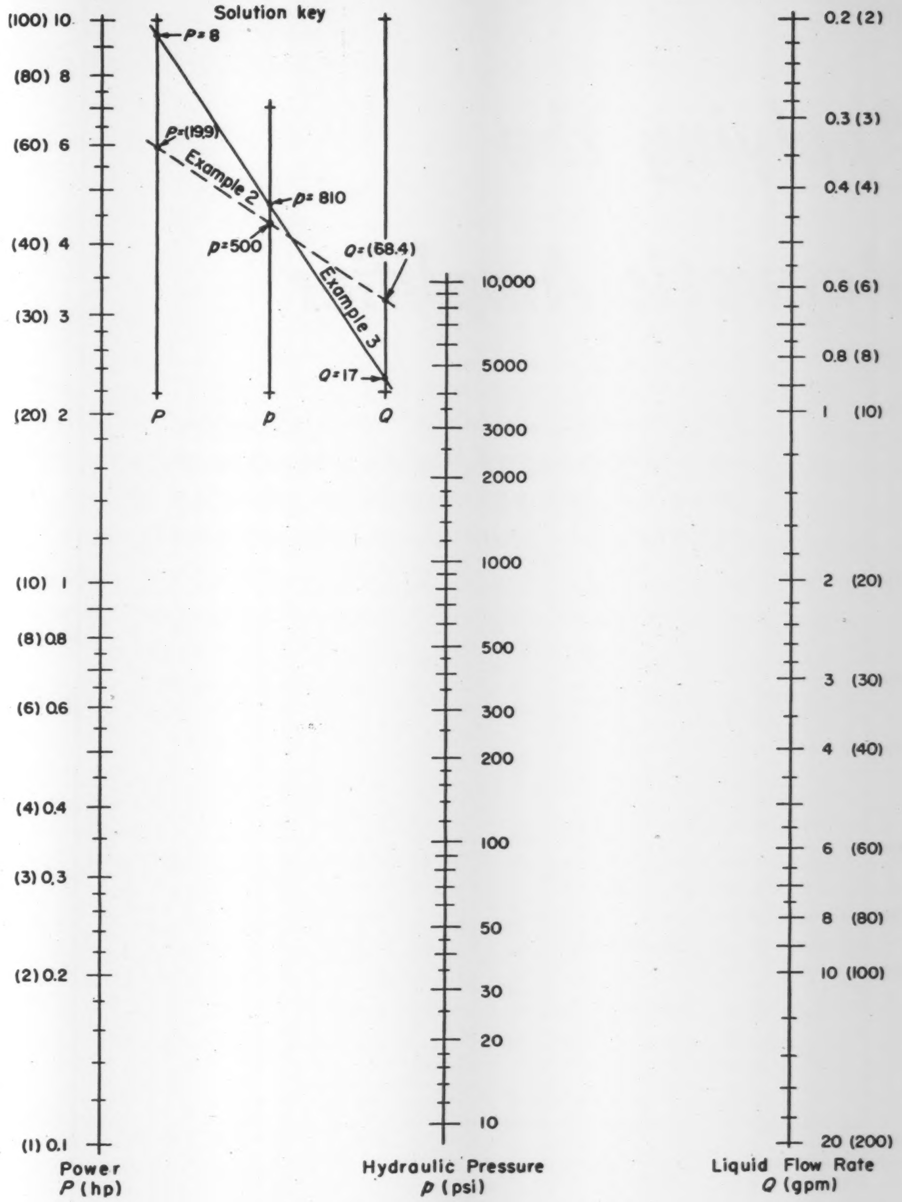


Fig. 5 — Alignment chart for determining hydraulic power, pressure, and liquid flow rate

lines. Then lay off a vertical line upward from the point $n = 1800$ rpm and cut across all length of stroke lines. By using a right triangle keeping the two legs parallel to the principal axes of the chart, position the triangle so that the apex of the right angle lies within range of the area of piston lines while the two triangle legs intersect the previously laid out lines within the range of the number of pistons lines and length of stroke lines. By moving and scanning the right triangle, suitable length of stroke, area of piston, and number of pistons can be arbitrarily selected to meet the design specifications. Therefore, one of many practical solutions to this problem, within the range of good design practice, would be $N = 11$, $l = 0.7$-inch and $A = 0.57$ square inch. Since $A = \pi d^2/4 = 0.785d^2$, diameter of piston $d = 0.85$-inch. Referring to the *Fig.* 5 alignment chart, draw a straight line through given values $Q = (68.4)$ gpm and $p = 500$ psi and continue left until the power scale is intersected and read $P = (19.9)$ hp. However, since the mechanical efficiency of the pump is only 85 per cent, the actual horsepower needed is 19.9/0.85 = 23.5 hp.

EXAMPLE 3. This example illustrates the utility of the solution charts for determining the dimensions and characteristics of a hydraulic motor. Suppose it is required to design a hydraulic vane motor which will have an output power $P = 8$ hp at a rotational speed $n = 1500$ rpm. Assume a fluid flow input $Q_i = 20$ gpm is available, volumetric efficiency $\eta_V = 85$ per cent and mechanical efficiency $\eta_M = 90$ per cent. Since 20 gpm input is available the geometric displacement of the motor $Q_d = Q_i\eta_V = 20(0.85) = 17$ gpm. On the *Fig.* 5 alignment chart, connect with a straight line the points $Q = 17$ gpm and $P = 8$ hp which will intersect the pressure line at $p = 810$ psi. Since the mechanical efficiency is only 90 per cent, actual line pressure required is $p/\eta_M = 810/0.90 = 900$ psi.

To obtain the geometrical dimensions of the motor, on *Fig.* 3 lay off a horizontal line left from $Q = 17$ gpm cutting across all width of rotor lines. Also lay off a vertical line up from the point $n = 1500$ rpm cutting across all eccentricity lines. Following a procedure similar to the one outlined in Example 2, by moving and scanning a clear plastic triangle so the right angle apex falls in the vane pump housing diameter region, one of many practical solutions to this problem is $e = 0.138$-inch, $D = 4$ inches and $w = 0.75$-inch.

DESIGN ABSTRACTS

Applying the Magnetic Amplifier

Rugged and reliable, the magnetic amplifier is today finding widespread industrial acceptance in a growing number of control applications

By J. J. W. Brown
Industrial Engineering Section
Apparatus Sales Div.
General Electric Co.
Schenectady, N. Y.

WITH certain exceptions, the magnetic amplifier works similarly to most power amplifiers. A low-power input current controls a higher-power output current, the change in output being nearly proportional to the change in input, *Fig.* 1.

Typical steady-state characteristics of a magnetic amplifier, a rotating amplifier and dc generator, and an electronic amplifier are shown *Fig.* 2. The magnetic amplifier's normal operating range is selected so that its output increases almost linearly with input. The drooping upper portion of the curve is used only when the amplifier is overexcited or forced, for short periods of time, to obtain fast response. Although the curve is somewhat similar to the saturation curve of a dc generator, it will be noted that the magnetic amplifier's output doesn't reverse when the input signal is reversed. In fact, just the opposite happens; large values of reverse (negative) input current tend to increase output current in the forward (positive) direction.

This increase in output is opposite the normally expected results. And sometimes it can be most disconcerting if not considered in the design of a system. As a simple example of this effect, take a hypothetical situation where an operator is reducing the speed of a magnetic-amplifier-controlled dc motor drive. Were he to decrease the control signal beyond the point where it reversed (changed polarity) the drive would begin to pick up speed again. However, recent techniques have minimized and practically eliminated this undesirable portion of the magnetic amplifier's characteristic curve.

The magnetic amplifier is irre-

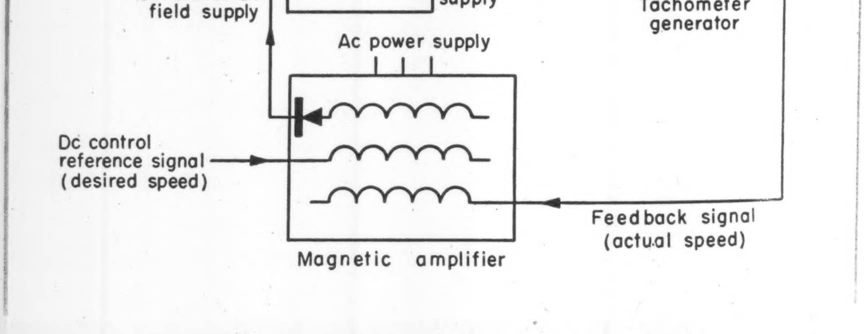


Fig. 1—Typical magnetic-amplifier control system. A dc signal applied to one or more control windings of the amplifier varies the magnetic permeability. Thus, the impedance to ac flow through an output winding is also varied to produce an amplifying action. Metallic rectifiers usually convert output to dc. In the system shown, the regulated quantity (actual speed) is compared with the input quantity (desired speed) and the difference is amplified to maintain an accurate balance between the two

versible because metallic rectifers are used in its output circuit. Where reversing characteristics are required, two magnetic amplifiers can be used whose outputs are opposed. This is, however, an extremely inefficient method. It is employed for relatively low power outputs where efficiency is of little concern.

As with all inductive circuits there is a time delay between the change in input signal to a magnetic amplifier and the corresponding change in its output. The time delay can be shortened by using a larger input signal, but this also reduces amplification. A series resistance can be added to the input winding to decrease input circuit reactance.

A magnetic amplifier's output appears as rectified pulses of its ac input. And if the magnitude of the input power is increased sufficiently, the theoretical minimum time delay—one half cycle of the ac supply frequency—can be approached. Thus, the higher the power-supply frequency, the faster the magnetic amplifier can be designed to operate. For this reason power-supply frequencies of 400 cycles per second for power magnetic amplifiers and in the kilocycle per second range for control magnetic amplifiers are quite common.

Characteristics of a magnetic amplifier are changed not only by variations in the ac supply voltage and frequency but also by changes in the load itself. Near maximum output conditions, the predominant factor limiting the load current is the load's impedance.

Maximum load is defined as that load at which there is a maximum output power change for a given input power change. If the ac supply voltage increases, the output will increase for a fixed input signal. Likewise, if the ac supply voltage decreases, the output will decrease for a fixed input signal. For both a fixed ac supply voltage and input signal, a decrease in the supply frequency will have approximately the same effect as an increase in the supply voltage, and vice versa.

Operating Characteristics: One way to judge the true worth of the magnetic amplifier is to compare its characteristics and features with those of competitive devices; namely the electronic and rotating amplifiers.

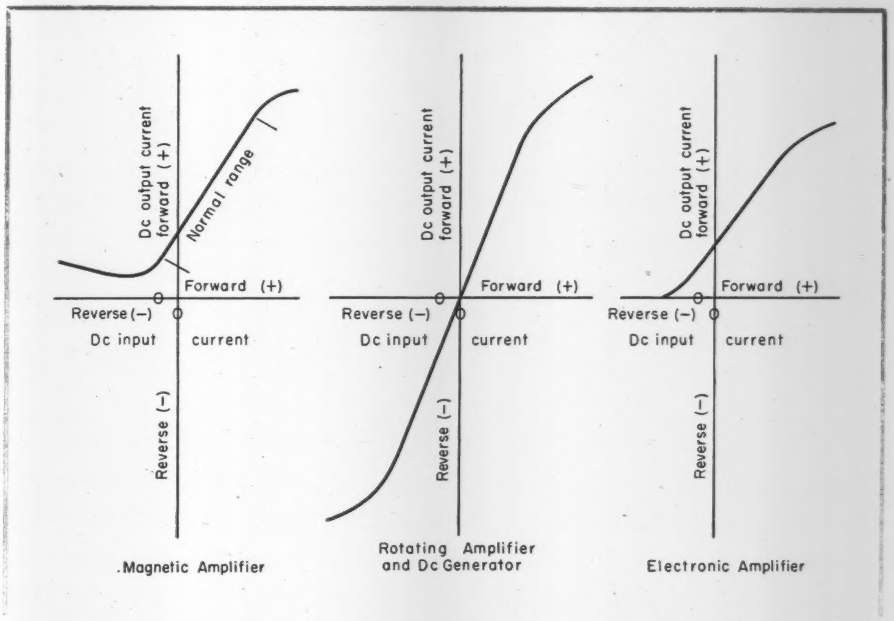


Fig. 2—Comparison of steady-state characteristics for three types of electrical amplifiers. Magnetic amplifier, like the electronic amplifier but unlike the rotating amplifier, is nonreversing; a reversed input signal increases its output in the forward direction

For reliability, the magnetic amplifier is preferable to the electronic amplifier. What it amounts to is a choice between an amplifier with long-lived, stable and rugged components versus one equipped with vacuum tubes having a long but still unpredictable life.

From the maintenance standpoint the magnetic amplifier is preferable to the rotating amplifier on the basis of a completely static device versus one with bearings, brushes, and a commutator.

In speed of response the magnetic amplifier, in general, can only equal the rotating amplifier with difficulty. It can only approach the electronic amplifier in speed if it is designed for a high-frequency power supply; say, 1000 cps or higher.

For reversing applications the rotating amplifier is supreme. The magnetic amplifier shares with the electronic amplifier the irreversible characteristics of the rectifier, whether metallic or vacuum tube. On the other hand, it shares with the rotating amplifier the distinction of having its various input signals completely isolated. Because of this, magnetic amplifiers can be readily connected in series.

Further, a magnetic amplifier's components can be sealed for protection against adverse environmental conditions. And it can be constructed to withstand shock and vibration better than either rotating or electronic amplifiers.

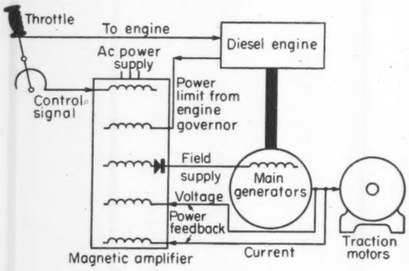
Application Considerations: In many applications a magnetic amplifier is used where its only advantage is the character of its components. In other words, the amplifier's reactors, metallic rectifiers, and resistors can all be mounted in cabinets containing relays, contactors, and meters of the over-all system. Also, because the magnetic amplifier can be completely sealed, high-altitude and similar environmental applications can dictate its use.

For applications where only a few watts output is required, the magnetic amplifier will be smaller than either the electronic or rotating amplifiers. In this instance all its components can be sealed in a single can.

Because magnetic amplifiers are

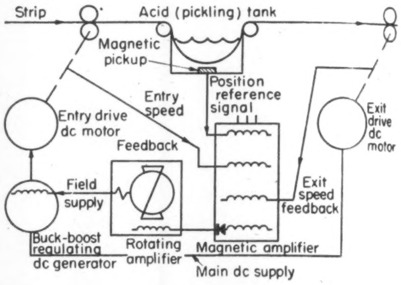
Fig. 3—Typical industrial applications of the magnetic amplifier

TRANSPORTATION


Throttle
To engine
Diesel engine
Ac power supply
Control signal
Power limit from engine governor
Field supply
Voltage
Main generators
Power feedback
Traction motors
Magnetic amplifier
Current

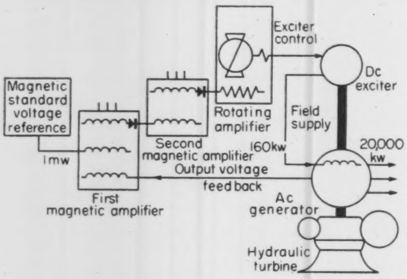
Diesel-Electric Locomotive: Excitation of main generators is regulated by magnetic amplifier, controlling speed and acceleration of traction motors in response to throttle setting. Signal from diesel engine governor sets up a power limit and reduces wheel speed when more tractive effort is needed, thus preventing engine from "lugging down"

STEEL


Strip
Acid (pickling) tank
Magnetic pickup
Position reference signal
Entry drive dc motor
Entry speed
Feedback
Exit drive dc motor
Field supply
Exit speed feedback
Buck-boost regulating dc generator
Rotating amplifier
Magnetic amplifier
Main dc supply

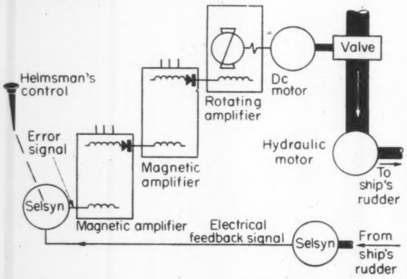
Pickling and Cleaning Process: Speed of steel strip is regulated by magnetic-loop control which employs magnetic and rotating amplifiers. Acid-resistant pickup assures maximum footage of steel in pickling tank without allowing strip to drag. Output of pickup, which depends on proximity of strip, is amplified to regulate entry speed

HYDROELECTRIC


Exciter control
Dc exciter
Magnetic standard voltage reference
Rotating amplifier
Field supply
Second magnetic amplifier
160kw
20,000 kw
1mw
Output voltage feedback
First magnetic amplifier
Ac generator
Hydraulic turbine

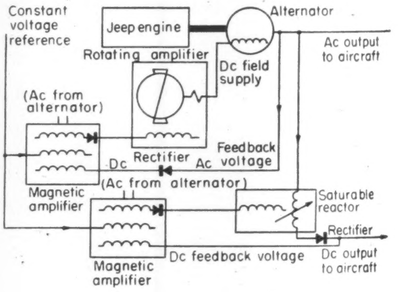
Turbine-driven Generator: Ac output voltage is regulated by combination of magnetic and rotating amplifiers. Deviations of output voltage from a magnetic standard reference are detected and amplified by two stages of magnetic amplifiers, a rotating amplifier and a conventional dc exciter

MARINE


Valve
Helmsman's control
Dc motor
Rotating amplifier
Error signal
Hydraulic motor
Magnetic amplifier
To ship's rudder
Selsyn
Magnetic amplifier
Electrical feedback signal
Selsyn
From ship's rudder

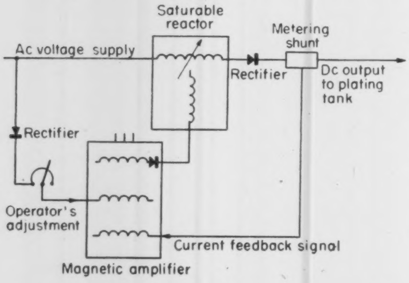
Destroyer Steering Engine: Error signal from two electrically connected selsyns, which compare position of helmsman's control lever with that of rudder, is amplified by magnetic amplifier to excite rotating amplifier. The latter device excites a dc motor that opens or closes a valve to control the hydraulic motor which moves the rudder

AIRCRAFT


Constant voltage reference
Jeep engine
Alternator
Ac output to aircraft
Rotating amplifier
Dc field supply
(Ac from alternator)
Feedback voltage
Dc
Rectifier
Ac
Magnetic amplifier
(Ac from alternator)
Saturable reactor
Rectifier
Magnetic amplifier
Dc feedback voltage
Dc output to aircraft

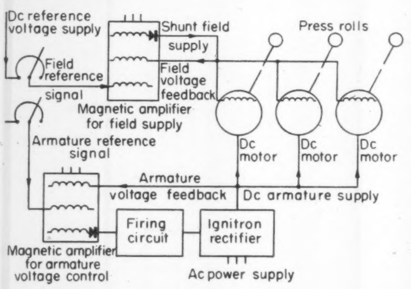
Turbojet Mobile Power Supply: Rectified output voltage from alternator driven by jeep engine is held constant by a series saturable reactor. A magnetic amplifier controls the impedance of the reactor by comparing output voltage with a constant reference voltage

ELECTROPLATING


Saturable reactor
Metering shunt
Ac voltage supply
Rectifier
Dc output to plating tank
Rectifier
Operator's adjustment
Current feedback signal
Magnetic amplifier

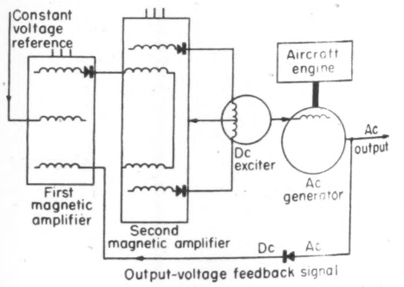
Automatic Process Control: Feedback signal from a dc metering shunt, used to measure large currents of electroplating process, is amplified by magnetic amplifier which compares the signal to operator dial setting and controls of the impedance of the saturable reactor. The system prevents large power losses

PRINTING


Dc reference voltage supply
Shunt field supply
Press rolls
Field reference signal
Field voltage feedback
Magnetic amplifier for field supply
Armature reference signal
Dc motor
Dc motor
Dc motor
Armature voltage feedback
Dc armature supply
Firing circuit
Ignitron rectifier
Magnetic amplifier for armature voltage control
Ac power supply

High-Speed Press: Ignitron rectifier, controlled by a magnetic amplifier feeding firing circuit, supplies power to dc shunt drive motors. Second amplifier controls motor shunt field supply. Combination provides 50/1 speed range. The magnetic-amplifier controlled ignitrons for this service are rated 150 to 300 kilowatts

AIRCRAFT


Constant voltage reference
Aircraft engine
Ac output
Dc exciter
Ac generator
First magnetic amplifier
Second magnetic amplifier
Dc
Ac
Output-voltage feedback signal

Ac Generating Equipment: Output of ac generator is regulated by a magnetic amplifier in combination with a dc exciter. First amplifier amplifies difference between a reference voltage and a rectified portion of ac output. Amplified difference signal controls a second amplifier, designed to supply reversing output, which energizes dc exciter essentially power amplifiers, they are particularly useful for low-voltage high-current applications. Still, they can be designed in the same physical size to accommodate any combination of voltage and current for a given power output. By way of contrast, electronic amplifiers are voltage amplifiers with essentially high-voltage low-current outputs. And for higher-current outputs, larger electronic amplifiers must be resorted to because voltage amplification is inherent to them.

In the higher power ratings—10 kilowatt and above—a magnetic amplifier becomes quite large and bulky. It needs more room than an equivalent-rated rotating amplifier. And for reversing output its size would be almost prohibitive. In addition, maintenance and the possiblity of trouble increases in the higher power ratings. A 10-kilowatt rotating amplifier, on the other hand, needs no more maintenance and is no more likely to fail than a unit rated 1 kilowatt.

As stated before, the input signal to a magnetic amplifier is completely isolated from the output signal, a particularly useful feature when several input signals must be employed to control an output. Again, in this application the magnetic amplifier is most useful in the low power range—500 watts or less—where a rotating amplifier is quite large and bulky in comparison. An isolated input, incidentally, is difficult to obtain with the electronic amplifier.

Magnetic amplifiers can be designed for greater long-term electrical stability than either the rotating or electronic amplifiers. And so they are the logical choice for metering applications or for amplifying the output of millivolt shunts and thermocouples. Their long-term stability suits them particularly to pure amplifier applications where no feedback is used and where variations in characteristics would affect output directly.

The magnetic amplifier is employed in many diverse applications, *Fig.* 3. A partial list would include amplifying the minute outputs of photocells and ionization chambers, controlling the output of arc welders and the speed of paper-mill drives, and obtaining isolation in metering circuits involving thousands of amperes. Magnetic amplifiers have been applied to systems ranging from compact autopilots for aircraft to the largest high-speed motor drives for steel mills; from the regulation of voltages of miniature aircraft alternators to regulation of those of huge steam-turbine-driven utility generators.

Final Evaluation: In all its applications, the magnetic amplifier has proved to be sturdy, reliable, and effective. But its true value can only be determined after making a thorough analysis of the application itself. For one purpose it may be superior to all other amplifiers; for another, it may be the poorest choice.

All of this means that the magnetic amplifier will not replace the electronic or rotating amplifiers in the immediate future. Instead, it will remain an additional amplifier tool with clear-cut advantages for some applications and equally clear-cut handicaps for others. Although the magnetic amplifier will no doubt take an equal position with its predecessors, the electronic and rotating amplifiers, it will not necessarily take a dominant one.

From an article entitled "How Good is the Magnetic Amplifier" appearing in the General Electric Review *for July,* 1954.

Electrical Insulating Properties of

Plastic Laminates

By Norman A. Skow
Director of Research
Synthane Corp.
Oaks, Pa.

THERMOSETTING laminated plastics are used extensively for electrical insulation because of their unusual combination of electrical, mechanical and chemical properties. Mechanically strong, light in weight, and easy to fabricate, these materials resist chemical corrosion, moisture, aging, heat and temperature deterioration.

To establish safe operating limits, tests for the endurance limits of dielectric strength were run on each of several grades of thermosetting plastic laminates, plotting voltages against time. The data thus obtained indicate that, for a given thickness and atmospheric condition, a maximum voltage exists below which failure will not occur. Tests of this type yield results which are valuable in determining the proper grade and thickness of material for use as insulating parts in electrical equipment applications.

Insulating Properties: In selecting an electrical insulating material, the designer is primarily concerned with insulation resistance, dielectric loss and dielectric breakdown. The relative importance of these various properties depends on the application involved, but dielectric breakdown is almost always a major consideration.

As defined by ASTM, the dielectric strength of an insulating material is the maximum potential gradient that the material can withstand without rupture. This property is difficult to evaluate quantitatively because its magnitude varies with temperature, thickness of material, moisture content, and time exposed to stress. In general, the dielectric strength of insulating materials decreases with time of exposure to the electrical stress.

When the maximum voltage that can be applied for an indefinite time without breakdown has been found, the endurance limit of dielectric strength has been established.

Differences between the dielectric breakdown properties of thermosetting laminates stressed parallel to laminations and those stressed perpendicular to laminations are sufficient to warrant investigation of behavior for each direction. The same dielectric strength and endurance characteristics do not exist where laminated sheets are used as insulating spacers (stressed perpendicular to lamination), and where laminates are used as terminal-board insulators (stressed parallel to lamination).

To obtain the results presented here, seven standard NEMA grades of laminated thermosetting plastics were tested: X, XX, XXXP, LE, A, G-5 and N-1. These particular grades were selected because they are typical of the entire group. Although these test results are only based upon laminates in sheet form, the dielectric properties of tubes, rods and molded parts are quite similar.

Grades X, XX and XXXP are paper-base laminates bonded with phenolic resin. Grade X is intended primarily for mechanical applications and should be used with discretion under high-humidity conditions. Grade XX is made with a more absorbent paper and has a higher resin content than Grade X. Grade XX is better electrically, although slightly weaker mechanically, than Grade X. Grade XXXP, which has a still higher resin content, is one of the best electrical laminates produced. Grade LE has a cotton-fabric base and is bonded with phenolic resin. This grade is used on electrical applications requiring greater toughness than is provided by Grade XX.

Grade A is an asbestos paper-base laminate bonded with phenolic resin. It is more flame and heat-resistant than the cellulosic grades. Bonded with melamine resin, Grade G-5 is a glass-base laminate with very high mechanical strength, excellent electrical properties under dry conditions and good heat, flame and arc resistance. Grade N-1 is a nylon-fabric base laminate bonded with phenolic resin. It has excellent electrical and mechanical properties even under high humidity conditions.

Analysis of Test Data: From the results of tests in both directions for Grades XX, XXXP, and N-1 at temperatures from 65F to 256F, curves of breakdown voltage versus temperature have been plotted in ***Fig.* 1**. Two significant facts are readily apparent. (1) Short-time dielectric strengths parallel to laminations are lower than those perpendicular to laminations (with the exception of Grade XX at temperatures above 180 F); and (2) the differences in dielectric strength versus temperature characteristics parallel to laminations are comparatively small.

Grade XXXP laminate has the highest dielectric strength perpendicular to laminations within the temperature range covered, and the drop in breakdown voltages is very small between 90 F and 180 F. This gradual change in breakdown voltage up to 180 F is of particular advantage when laminated plastic components are subjected to hot-spot temperatures in electronic equipment.

There is a rapid decrease in the breakdown voltage of even Grade XXXP as the temperature is further increased. Breakdown characteristics of the three grades parallel to laminations are more nearly equal. This indicates that it makes little difference in regard to short-time dielectric strength as to which of the three grades is selected for operation at temperatures within the range covered.

Parallel to laminations, Grade N-1 (nylon-base laminate) has the most rapid decrease in short-time dielectric strength with temperature, while the breakdown voltages of Grade XXXP, although it has a lower dielectric strength at lower temperatures, drop slightly between 65 F and 256 F. The breakdown voltages of Grade XX appear between these two extremes throughout the temperature range.

As to effect of sample thickness on the short-time dielectric strength measured in both directions, the dielectric strength of Grade XX plastic laminate, measured perpendicular to lamination for a ⅛-inch thickness was found to be slightly more than half the magnitude for a 1/32-inch sample thickness. Dielectric strengths parallel to laminations, measured at five thicknesses ranging from 1/16 to ½-inch, are very close for Grades X and XX with sample thicknesses greater than ⅛-inch. The decrease in dielectric strength may be compared to the law of diminishing returns in that each additional thickness of laminate provides a smaller increase in the total dielectric breakdown voltage of the sample.

To determine the effects of conditioning, the short-time dielectric strength of Grade XX laminate

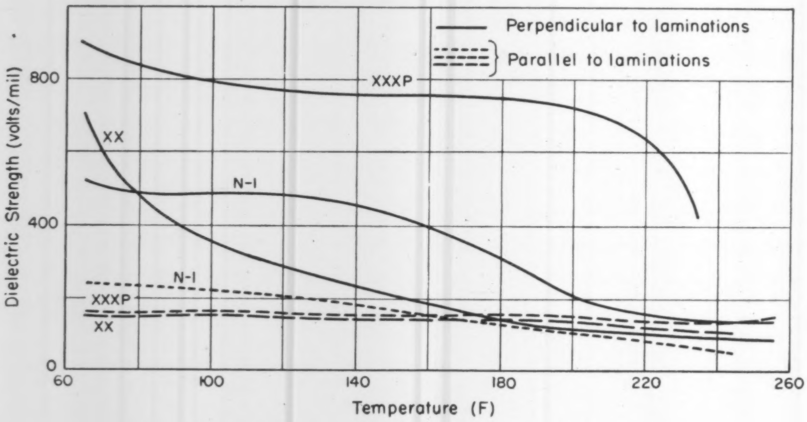


Fig. 1—Effect of temperature on short time dielectric strength for three standard NEMA grades of thermosetting laminates

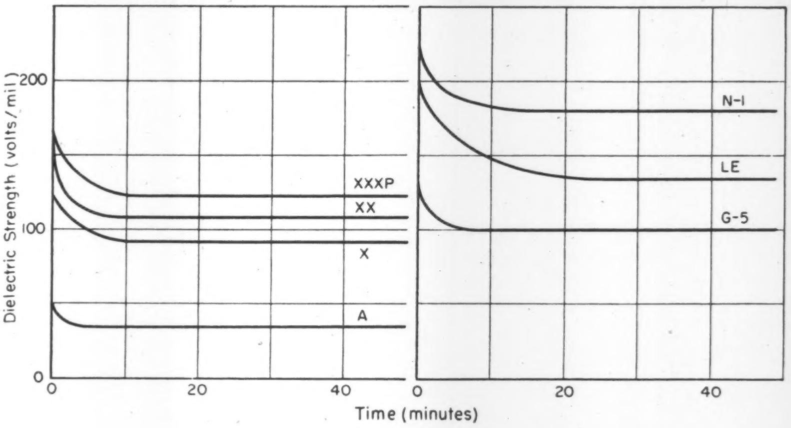


Fig. 2—Endurance limits of dielectric strength, parallel to laminations, for seven typical NEMA grades of thermosetting laminates. Curve data was obtained with samples of 1/4-inch thickness, tested dry at 73 F

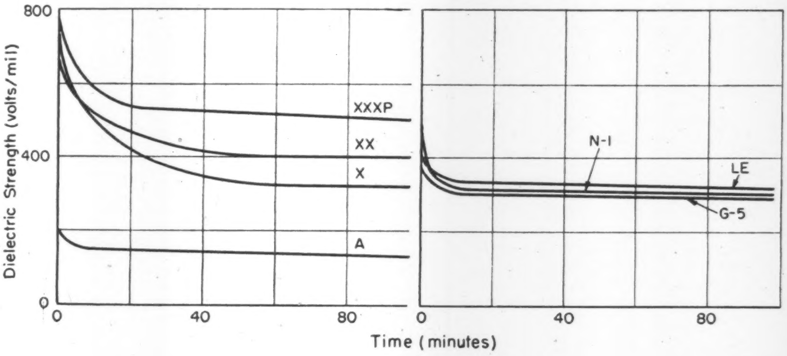


Fig. 3—Endurance limits of dielectric strength, perpendicular to laminations, for laminates of *Fig. 2*

was measured in both directions for various combinations of time, temperature and moisture treatment. Conditioning for a maximum of 4 days for measurements perpendicular to laminations was sufficient, but 21 days were necessary to insure uniform moisture absorption for obtaining breakdown voltages parallel to laminations. Because dielectric strength varies widely with changes in conditioning treatment, considerable care was taken to standardize the sample conditioning prior to dielectric strength tests.

Endurance limits, perpendicular and parallel to laminations, for the seven grades of laminates tested are given in *Figs.* 2 and 3. The dielectric strength of all grades in both directions decreases rapidly with time until it is approximately 60 to 70 per cent of the short-time dielectric strength. The curves show that the breakdown voltage, or upper limit of voltage gradient without rupture, gradually approaches a magnitude that is independent of time. The endurance limit of the material is considered approximately equal to the maximum dielectric strength which will not rupture after a 100-minute exposure to stress.

Test Conclusions: Grade A, asbestos-base plastic laminate has the lowest dielectric strength and endurance limit in either direction but is recommended in high-temperature applications because of its superior heat resistance. The six remaining grades tested are suitable for high-voltage applications, Grade XXXP having the highest breakdown voltages perpendicular to laminations and Grade N-1 the highest parallel to laminations.

For dry specimens, the endurance limits (in either direction) of the seven standard grades of laminates tested vary from 49 to 84 per cent of the corresponding short-time dielectric strength. Therefore the designer can consider a safety factor of three, based on the short-time test, to be sufficient. For Grades XX and XXXP exposed to high humidity and elevated temperatures, the percentage ratio of endurance limit to short-time dielectric strength ranges from 47 to 86 per cent (including both directions). Again, a safety factor of three should be satisfactory. In actual practice, a designer may expect to use equipment under highly humid conditions, yet available data on the laminates may be limited to short-time dielectric strength under dry conditions. In these cases, a safety factor of six may be necessary.

Conclusions drawn from these tests would indicate that for selecting thermosetting plastic laminates to be used as a dielectric medium, it is important to know the temperature at which the equipment is to be operated, the atmospheric conditions to be encountered, the mechanical strain and the dielectric stress to be applied. If the equipment is used under dry conditions and the mechanical strength requirements are not severe, paper-base laminates are very satisfactory. If humid conditions are a factor it would be advisable to use the more water-resistant paper base grades such as Grade XXXP. Under dry conditions requiring high mechanical strength it may be necessary to use a fabric grade such as LE, and under continuous humid conditions requiring high mechanical strength it may be necessary to use Grade N-1. If arc resistance is an important requirement, Grade G-5 is indicated.

From a paper entitled "Dielectric Breakdown Properties of Thermosetting Laminates" presented at the ASME Semi-Annual Meeting in Pittsburgh, Pa., June, 1954.

Changing Trends in

Mechanical Fasteners

By W. C. Stewart
Technical Adviser
Industrial Fasteners Institute
Cleveland, O.

A MARKED trend in fastening is toward higher-strength fasteners. In heat-treated carbon steel, tensile strengths of well over 100,000 psi are not uncommon. This classification of fasteners has recently been standardized as SAE Grade 5, and is also covered in ASTM specification A325. Where strength is a factor, this grade provides the most strength per dollar of fastener cost. Higher strengths are available in alloy steels, but generally at increasing relative cost.

Higher fastener strength provides several advantages. Smaller fasteners, fewer fasteners, or both, can be used in a particular application, providing lower weight, more compactness of design, and lower cost. Weight is saved not only in the fasteners themselves but also in the assembled parts due to reduction in size of flanges and similar attachment projections. Improved fastener functioning may also result since smaller fasteners often can be placed nearer the line of loading, resulting in less eccentric load or bending on the fastener.

An important advantage of higher fastener strength is that it permits higher clamping force when the fastener is fully tightened. This high clamping force is useful in many ways: It helps prevent fatigue of the fastener and also of the fastened parts; it provides a degree of locking to prevent loosening due to vibration and shock; and it provides tightness against fluid or gas leakage.

A broad trend in fastener invention is the development of means for reducing the cost of application of fasteners. The cost of installing a fastener may be five, ten or fifty times as much as the cost of the fastener itself. It is safe to say that an important part of all human labor in factories is spent in applying fasteners to turn useless parts into useful assemblies. Engineers should be intensely interested in methods of reducing this high cost of application of fasteners. A large part of the creative effort of the fastener industry is directed toward helping to accomplish this objective.

The following discussions highlight some of the important trends in the different fastener types.

Locknuts: Possibly more imagination has been exercised in designing locknuts than in any other mechanical device. While some of these inventions have not proved successful, about thirty locknuts are being made and used commercially today, *Fig.* 1.

A locknut, in addition to serving the purposs of an ordinary nut, has a special means for gripping a threaded member so that relative rotation between the nut and the threaded companion member is prevented in use. Locknuts may be sub-divided into (1) "prevailing-torque" types which lock at any position on the bolt, and (2) "free-running" types which are assembled freely and develop locking only after being torqued into position. The specific types of locknuts differ in the locking means. As a result, they all have somewhat differing characteristics. As yet no laboratory test has been devised that will exactly predict how a given locknut will

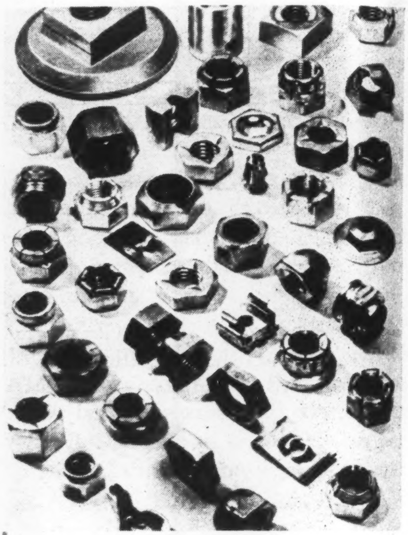


Fig. 1—Common types of commercial locknuts

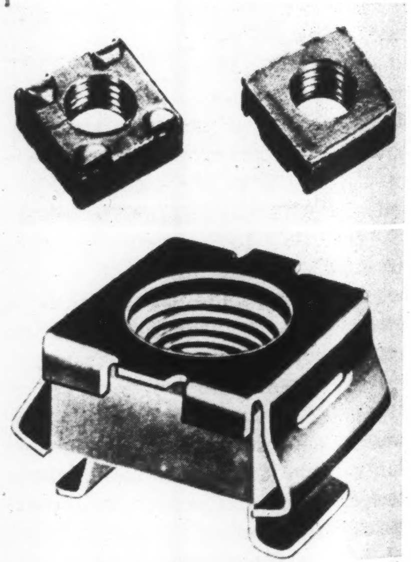


Fig. 2—Typical weld nut, top, for rigid attachment to workpiece and cage-nut variation, below, which has floating action to compensate for misalignment

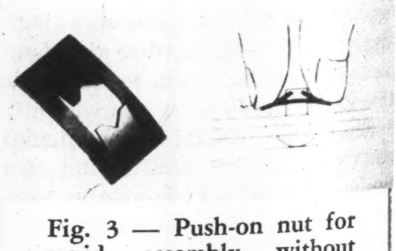
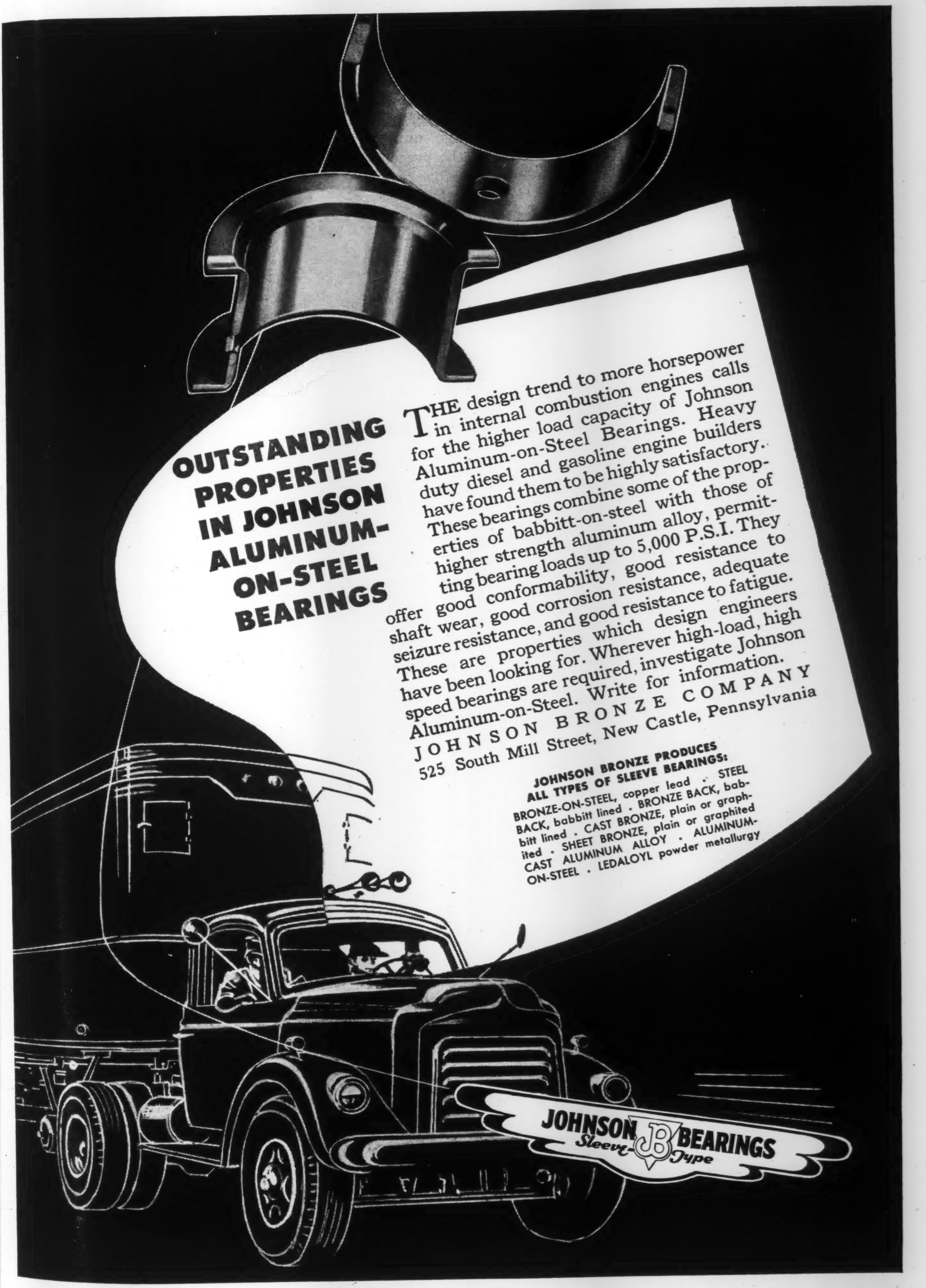


Fig. 3 — Push-on nut for rapid assembly without screw threads



OUTSTANDING PROPERTIES IN JOHNSON ALUMINUM-ON-STEEL BEARINGS

THE design trend to more horsepower in internal combustion engines calls for the higher load capacity of Johnson Aluminum-on-Steel Bearings. Heavy duty diesel and gasoline engine builders have found them to be highly satisfactory. These bearings combine some of the properties of babbitt-on-steel with those of higher strength aluminum alloy, permitting bearing loads up to 5,000 P.S.I. They offer good conformability, good resistance to shaft wear, good corrosion resistance, adequate seizure resistance, and good resistance to fatigue. These are properties which design engineers have been looking for. Wherever high-load, high speed bearings are required, investigate Johnson Aluminum-on-Steel. Write for information.

JOHNSON BRONZE COMPANY
525 South Mill Street, New Castle, Pennsylvania

JOHNSON BRONZE PRODUCES ALL TYPES OF SLEEVE BEARINGS:

BRONZE-ON-STEEL, copper lead . STEEL BACK, babbitt lined . BRONZE BACK, babbitt lined . CAST BRONZE, plain or graphited . SHEET BRONZE, plain or graphited . CAST ALUMINUM ALLOY . ALUMINUM-ON-STEEL . LEDALOYL powder metallurgy

JOHNSON BEARINGS
Sleeve-Type

perform in a specific operation. The best test, therefore, is how well the particular locknut performs under actual service conditions.

There are several special nuts which do not fall into the category of locknuts but perform a service by locking to the workpiece itself rather than to the male threaded member. Such nuts work well when the male member is fixed to the work parts or otherwise prevented from turning. Then, when the nut also locks to the work parts the assembly is completely locked up.

Prefixed Nuts: A group of special nuts are produced which are designed to be rigidly prefixed to the workpiece by welding, clinching, pressing or staking, *Fig.* 2. This saves considerable time in later assembly as the workman can install the bolt blindly and without the necessity of handling a nut. Some care should be taken in positioning the nut as it is being fixed to the work so that the nut is not cocked or out of line with respect to the bolt.

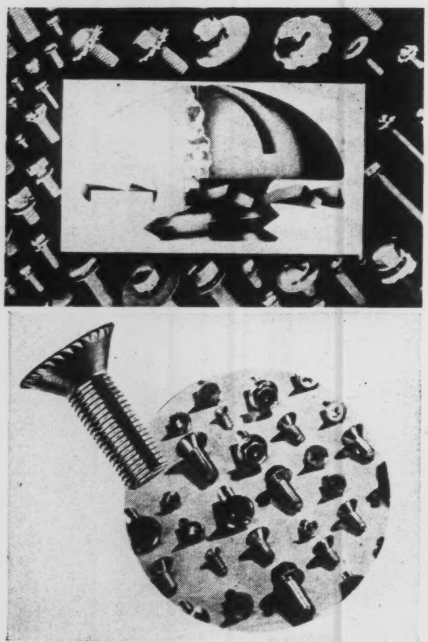


Fig. 4—Two methods of locking screw heads showing, top, preassembled lockwasher and screw types and, below, screw with locking teeth in head

Cage nuts, *Fig.* 2, are a variation of the type of nut just described. The nuts are assembled somewhat loosely into a cage which is prefixed to the workpiece by welding, riveting, or snapping into place. Cage nuts have the advantages of the preceding group but in addition, by reason of the nut "floating" in a cage, they avoid the difficulties resulting from poor positioning of a fixed nut. A useful variation of cage nuts is the "gang" or "tandem" assembly of a number of nuts into a strip, which can save extra time when a row of fasteners is to be assembled.

Push-On Nuts: Several variations of nuts are available which are designed to be simply pushed on a cylindrical pin without screw threads, *Fig.* 3. They push on easily but resist removal and, where applicable, save time since the fastener does not have to be screwed up in assembly.

Internal Wrenching Nuts and Bolts: There are several nut and bolt types which are assembled with an internal wrench by means of a socket in the top of the nut or bolt head. This permits the nut or bolt head to have a cylindrical external contour without hexagon or square corners. These fasteners are advantageous in confined quarters, permitting compactness of design by elimination of wrench clearance.

Head Locking Fasteners: Numerous devices are available for locking a screw head. Familiar types are lockwashers of the toothed or split spring type. A convenient variation is the use of preassembled lockwashers and screws, *Fig.* 4. By this method only one part must be handled, facilitating assembly. A recent development for locking screw heads in which locking teeth are incorporated in the screw head itself is shown in *Fig.* 4. These designs are available in several head styles.

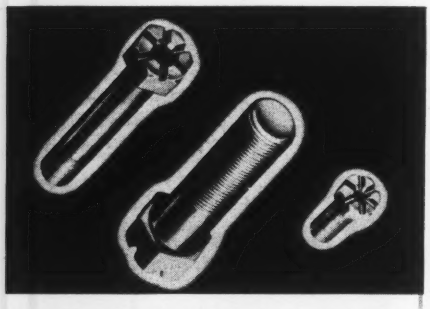


Fig. 5—Locking bolts with slotted, elastic head to provide holding action

Locking of the bolt or screw head may also be accomplished by increasing the elasticity of the fasteners. A widely used fastener, *Fig.* 5, does this by providing a slotted, elastic head which deflects under load and increases the overall elasticity of the fastener.

Locking Fasteners for Tapped Holes: Several fasteners are designed to lock in tapped holes. One accomplishes this by use of a special thread form on the screw which provides interference as it is torqued into the tapped hole. This drive fit results in intimate contact, under pressure, between mating threads, giving a locking effect.

Other variations for the same purpose incorporate a transverse nylon plug in the threaded section of the screw. The plastic plug provides the locking as the screw is assembled in a tapped hole.

Recessed-Head Screws: Convenience and ease of driving of screws may be accomplished by the use of specially shaped head recesses or sockets, *Fig.* 6. These sockets are fitted by mating drives. Recessed-head screws are better appearing than standard slotted screws and are adapted to rapid power driving.

Tapping Screws: A natural striving for decrease in assembly cost has led to the development of self-tapping screws. These screws have the usual head styles but

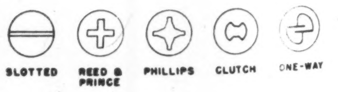
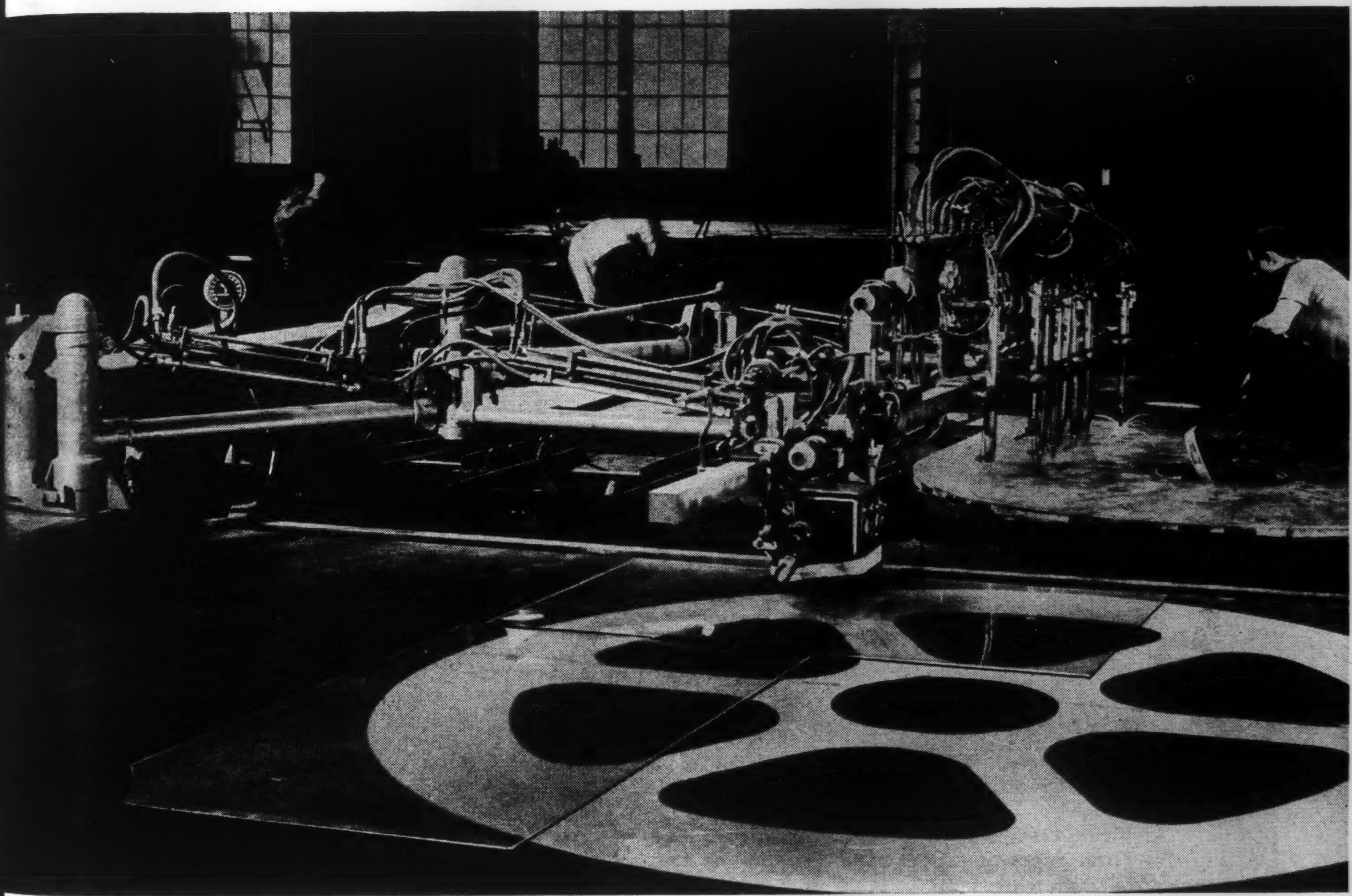


Fig. 6—Types of screw head sockets for use with power drivers

CONTINENTAL

STEEL FABRICATIONS AND WELDMENTS

Components or Assemblies



Custom or Production?—Save time and Money!

Here's one reason why Continental-made weldments can save you time and money. This multi-head flame cutter, guided by an electric eye, can cut up to eight shapes at once—from any metal that can be burned with oxygen or oxygen and powder. Working from paper templates, it saves pattern costs.

For welded components or complete assemblies—one of a kind, or quantity production—Continental's modern equipment and methods offer you design flexibility and production economy.

WRITE

for this new Brochure D
on Continental Weldments.

COMPLETE ROLLING MILLS • ROLLS
STEEL CASTINGS • WELDMENTS
BOILER CONTROLS AND CLEANING

Plants at
East Chicago, Ind. • Wheeling, W. Va. • Pittsburgh, Pa.
Copes-Vulcan Division: Erie, Pa.

CHICAGO • PITTSBURGH

CONTINENTAL
Foundry & Machine
Company

are hardened and may have special threads, permitting them to be screwed into sheet metal, plastics, wood, and other materials without the necessity of pretapping the holes. Being a one-piece fastener and requiring access to only one side of the work, they can be rapidly assembled. The combination of self-tapping, high hardness, and blind application make this a very versatile and economical fastener. They are classified by the type of screw thread provided, *Fig.* 7.

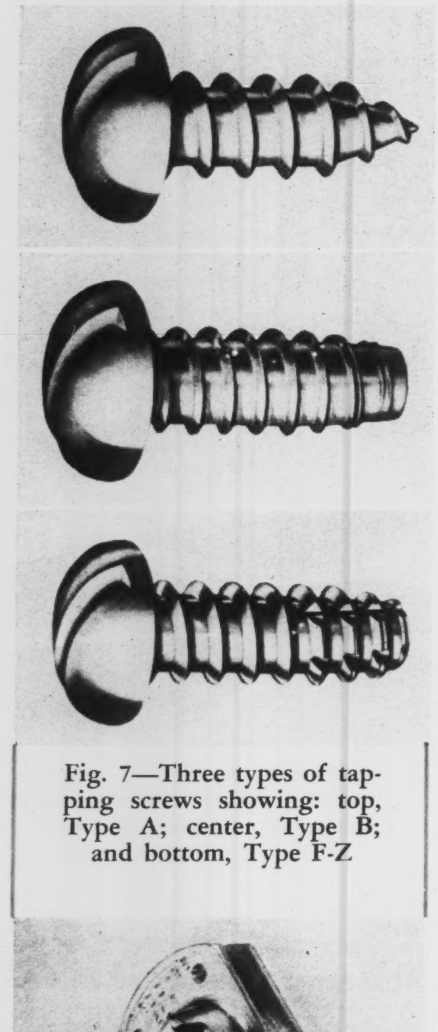


Fig. 7—Three types of tapping screws showing: top, Type A; center, Type B; and bottom, Type F-Z

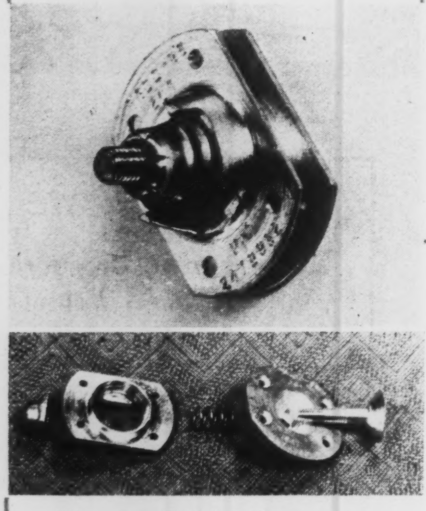


Fig. 8—Quick-release fastener designed to carry shear loads

Type A self-tapping screws, have a very coarse thread approximating that of a wood screw. They have a sharp point allowing fast assembly and easy entrance through slightly misaligned holes. This type of screw is frequently used in place of a common wood screw because of its greater strength. Threaded to the head, it is useful in fastening thin metal and wherever a short grip is required.

Type B (or Type Z) are blunt pointed but the point is tapered slightly to facilitate entry into pilot holes. While the screw resembles a standard machine screw, it has coarser threads which facilitate faster driving in assembly.

Type C (and variations such as Type F and Type F-Z) have threads of the same pitch as standard machine screws, either in the coarse or fine thread series. Because this screw has more threads per inch than other tapping screws, more torque is required to drive it, making it unsuitable for long thread engagement.

Drive Screws: These screws are an outgrowth of tapping screws and are also a case-hardened fastener. They have an extremely fast lead thread which permits the screw to be pressed or hammered into place without the necessity of torquing. The fastener is nonremovable and may be driven by special hopper-fed machines.

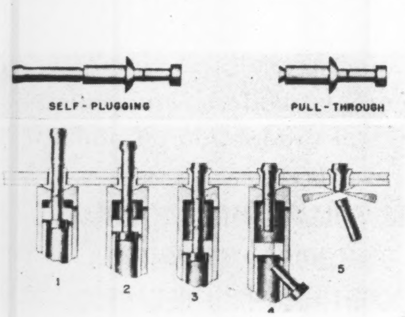


Fig. 9—Types and installation of cherry blind rivets

They provide a quick method of secure fastening and lend themselves to mass production.

Quick-Release Fasteners: Several ingenious designs of quick-release fasteners are available *Fig.* 8. As the name implies, the fastener may be tightened or released quickly and easily, usually by a quarter turn of a screw driver or other applicable tool. The fastener usually consists of two flanged parts which are separately fastened to the mating sheets and enable the sheets to be fastened or unfastened quickly by a small rotation of a connecting pin. They are primarily used to fasten inspection doors, cowlings, removable panels and any other attachment that must be removed quickly and frequently. Certain types of quick-release fasteners are specifically designed to carry high shear loads which increases the utility of this type.

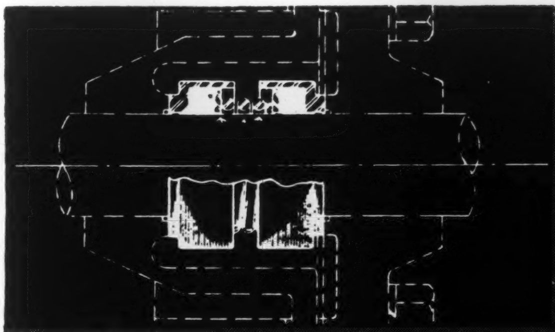
Blind Rivets and Bolts: A number of special rivets and bolts are widely used for blind applications, *Fig.* 9. As the name infers, the fasteners can be inserted and driven by one man from one side of the work. The head is formed on the far blind side by manipulation wholly from the front. Certain types of blind rivets are of two-piece construction. An internal pin having a head on the far end is pulled into the hollow rivet, upsetting its far end and fastening the joint. The pin may then be free to drop out or be pulled through, or it may be designed to plug the hole in the rivet, thus resulting in a higher load-carrying joint. Special driving tools are required.

Pressed-Fit Pin Fasteners: Several types of pin fasteners have been designed which can be pressed into a hole. They are constructed to maintain pressure against the walls of the hole and stay locked in place. Pins are easily and rapidly installed and may be used to fasten pulleys, gears, and levers on shafts, as dowels or locating pins, and for many other purposes.

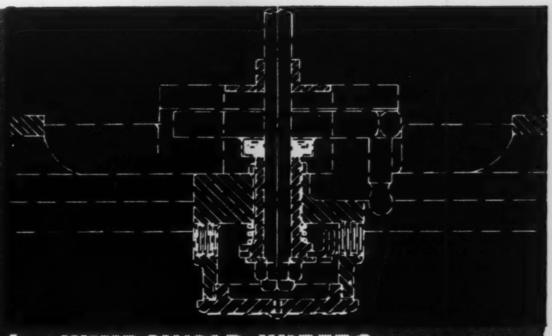
From a paper of the same title presented at the Twenty-Second Annual Meeting of the ASTE in Philadelphia, Pa., in April, 1954.

Stuck for the Right answer to a Shaft-Sealing problem?

TURN TO... ROTARY SEALS

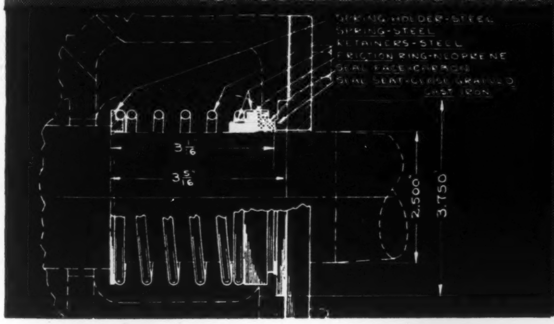


for SWITCHES

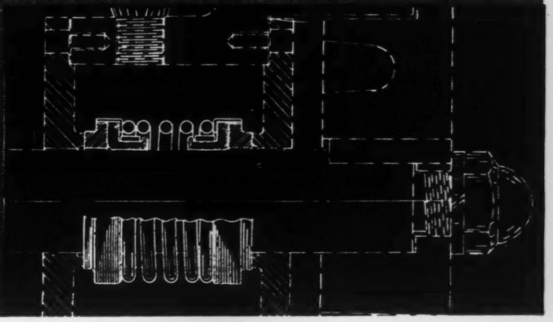


for WINDSHIELD WIPERS

for CONDENSING UNITS



for PUMPS



When ordinary methods won't do the job—yet *Shaft-Sealing Certainty* is a *must*—the proper ROTARY SEAL is usually the answer. ROTARY SEALS stop Shaft-Sealing troubles before they start, because they're *tailor-made* for each specific application.

The basic sealing principle originally introduced by ROTARY SEAL more than 20 years ago has naturally been imitated up to a point. But the broad experience of ROTARY SEAL engineers is inimitable. That experience makes it possible to adapt the basic ROTARY SEAL principle in just the right way—with the correct facings, springs and other details—to give you complete assurance of positive, trouble-free Seal performance under *your* conditions.

The illustrations above suggest only a few of the many successful uses of ROTARY SEALS. You'll find them "standard equipment" among leading makers of PUMPS—HYDRAULIC DEVICES—COMPRESSORS — APPLIANCES — GEAR BOXES—HEAVY DUTY WINDSHIELD WIPERS—AGRICULTURAL MACHINERY—and in scores of other applications where *Shaft-Sealing Certainty* is vital even under the most rigorous conditions.

The best time to start solving *your* Shaft-Sealing problem is at the drawing-board stage. Call in our engineers for an early consultation—and send for your copy of our brochure, *"Sealing with Certainty"*, which explains and illustrates the ROTARY SEAL principle.

THE ROTARY SEAL COMPANY
mechanical seals for rotating shafts

Shaft-Sealing with Certainty

2022 NORTH LARRABEE STREET
CHICAGO 14, ILLINOIS, U. S. A.

Helpful Literature

(Continued from Page 228)

35. Cold Forming

Mullins Mfg. Corp.—"How Would You Tool Up To Make An Egg" is title of 16-page illustrated booklet which covers the design possibilities of the Koldflo process of cold-forming tubular products from steel. Step by step illustrations are included on manufacture of an intricate balancing cup and of an accumulator shell 23-in. long. Process tolerances and other data are provided.

36. Air & Hydraulic Cylinders

Lindberg Engineering Co.—Information relative to air and hydraulic cylinders of heavy duty construction is provided in 4-page folder 5954. Air units operate on 150 psi maximum pressure, while hydraulic units range from 1500 to 3000 psi. Extra heavy duty mill type air cylinders which operate on 250 maximum pressure are described as well.

37. Industrial Filters

Cuno Engineering Corp.—Design and construction of line of Auto-Klean self-cleaning industrial filters is shown in illustrated 8-page catalog AK-050. Specifications and capacities are given also for standard models having flow rates between 1 and 3760 gpm for normal operating pressures of 125 psi. Filters are available for wide range of liquids, including oils, water and greases.

38. Plug Valves

Duriron Co., Inc.—Corrosion resistant type F plug valves described in 4-page illustrated bulletin V/4 are designed for severe chemical service. Valves are available in ½ through 2-in. sizes and are suitable for 150 psi service at up to 400° F. Teflon sleeves are used. Sampling valves are also shown.

39. Plunger Pumps

Worthington Corp.—Vertical triplex single action plunger pumps are covered in 12-page illustrated catalog W-414-B45. Pumps are offered for use in petroleum industry, water flooding and disposal, hydraulic press and hydraulic descaling systems. Ratings range from 2.1 to 225 gpm and discharge pressures up to 11,700 psi.

40. Electrical Indicating Instruments

DeJur-Amsco Corp.—Adaptable to most panel uses, round, square and rectangular standard range electrical indicating instruments are described in 4-page illustrated bulletin. Included are microammeters, voltmeters and ammeters. Complete specifications are given.

41. Variable Speed Pulleys

Reeves Pulley Co.—28-page well-illustrated bulletin V-545 describes redesigned Vari-Speed motor pulley line. Units are available in eight sizes from ½ to 15 hp and provide speed ratios up to 4:1. For use with new NEMA motors, they are smaller than previous models. Single-point lubrication is feature.

42. Heat Exchangers

Tranter Mfg. Inc.—20-page illustrated brochure 154 describes use of Platecoils in heat transfer applications. Field installation reports are featured, ranging from alkaline stripping and flexseal coating to tar transfer and quench oil cooling. Comparative performance data are provided.

43. Threaded Fasteners

Western Automatic Machine Screw Co.—36-page illustrated catalog wk-54 covers cap and set screws of various types, brass and steel hexagon nuts, stripper bolts, dowel pins, keys and key sets, pipe plugs and other allied products. Dimensions, prices and other ordering information are given in tabular form for easy reference.

44. Air-Tube Clutches

Wichita Falls Foundry & Machine Co—Air-tube clutches, rotary couplings, valves, V-belt pulleys, air compressor clutches, water pumps and air-tube catheads are covered in 4-page illustrated reprint. Clutch torque ratings are from 4,130 to 1,650,000 lb-in. at 100 psi air pressure. Design, construction and other details are presented.

45. O-Rings

Goshen Rubber Co., Inc.—12-page illustrated brochure gives detailed information on molded, die and lathe cut O-rings. Compounds available include natural and synthetic rubber, silicone and polyethylene and Teflon plastics. Groove dimensions, sizes and typical applications are also covered.

46. Casting Quality Control

Zenith Foundry Co.—20-page brochure takes reader on pictorial tour of company and illustrates how quality control enters into all phases of casting production with gray iron, alloy iron, semi-steel and Zenite. Sand control, metal control, cleaning, inspection and craftsmanship are factors considered.

47. Steel Casting Manufacture

Lebanon Steel Foundry—Entire process of steel casting manufacture from design and engineering phase to final applications is treated in 32-page brochure which has 70 illustrations. Considerable attention is given to centrifugal casting manufacture. Molding and coremaking, furnace tapping, pouring, heat treating, testing and inspecting and other phases are covered.

48. Structural Material

Goodyear Aircraft Corp.—32-page brochure describes and illustrates Bondolite, a high-strength, lightweight sandwich structural material. Originally developed for aircraft structure use, product's versatility creates applications in air, marine, rail and automotive transportation, building and furniture construction and other fields.

49. Cases & Enclosures

Artisan Metal Works Co.—Functional, protective and attractive features of company's housings, cases and enclosures are pointed out in bulletin. Typical units are illustrated.

50. Hydraulic Gear Pumps

New York Air Brake Co., Hydreco Div.—Series H pressure balanced oil hydraulic gear pumps designed for heavy duty machine tools, materials handling and earth moving equipment are subject of data bulletin 142. Pumps deliver 40-50-60-70 gpm at 1200 rpm and operate at up to 1500 psi.

51. Calculator

Technology Instrument Corp.—"Laboratory Report No. 7" of 4 pages presents the theory and application of the Servocalculator. Device, which is included in company's potentiometer kit B, aids in computing the necessary values of shunt resistors.

52. Company Facilities

New Britain Machine Co., Precision Products Div.—Typical screw machine products made by this company are illustrated in 16-page brochure which also shows engineering, tooling, inspection and production facilities.

53. Speed Variator Drives

General Electric Co.—Complete line of packaged speed variator drives from 1 to 200 hp is described in 20-page GEA-6127. Special attention is given to variator application in lumber, machine tool, textile and steel industries, as well as to use in materials handling.

54. Gear Drives

Falk Corp.—Compiled in 28-page bulletin 3100 are selection tables, dimensions, weights, overhung load ratings and thrust capacity ratings needed to select horizontal, vertical or right angle Motoreducers in either All-Motor or Integral design. Literature is practical for users of gear drives up through 75 hp.

55. Forging Facilities

American Car & Foundry Co.—28-pages present pictorial review of company forging facilities at work. Drop hammers, upsetters, presses and punches, shears, furnaces and specialized equipment are shown. Equipment for machining and die making, testing and analysis, as well as typical products are also shown.

56. Motocylinders

Westinghouse Corp. — The integral-type Motocylinder for material handling is described in 4-page booklet B-6090. Unit is adaptation of gearmotor, utilizing high-torque, high-slip electric motor and short, rugged crank on output shaft to transform rotary to reciprocating motion. How Motocylinders are employed to flip, turn, release, raise or lower material in repetitive cycles is described.

57. Terminal, Seals, Plugs

Hermaseal Co.—Electrical terminals, tubular button seals, glass seal tubes, multiple electrode headers, octal plugs, and grommets are described and specified in 24-page brochure. These components feature glass-to-metal sealing of electrodes. Specialty products are illustrated, as well.

58. Centrifugal Pumps

Gorman-Rupp Industries, Inc.—Three separate data sheets provide specifications and application data on three varieties of centrifugal pumps. A high capacity, low head, small pump for liquid moving and recirculating; a nonclogging molded rubber unit for coolant circulating; and series 9 noncorrosive draining units are covered.

59. Planetary Transmission

American Gear & Mfg. Co.—Full speed forward to full speed reverse takes only 1½ seconds with the Plan-Gear transmission, a compound planetary type, described and illustrated in 4-page folder 3270. Unit is rated 150 lb ft continuous input torque.

60. Telemetering

Bristol Co.—44-page expanded edition of bulletin M1710 illustrating and describing company's line of Metameter telemeters and accessories is now available. In addition to telemetering over telephone circuits, carrier current and private wires, bulletin features Microwave telemetering, telemetering with selective calling and time multiplexing telemetering. Categories cover measurement and transmission of pressure, flow, liquid level, mechanical motion, electrical units and totalized power load.

61. Ductile Cast Iron

International Nickel Co.—Data on machinability, gall resistance, compressive strength and other mechanical properties of ductile cast irons are provided in 8-page bulletin DI-2, a reprint from MACHINE DESIGN entitled "Engineering Applications of Ductile Cast Iron." Examples are given illustrating appropriate use of metal's properties in designing machine components.

62. Fractional HP Drives

Eaton Mfg. Co., Dynamatic Div.—Fractional horsepower Ajusto-Spede drives detailed in 8-page bulletin FAS are an integral combination of ac constant speed induction motors, eddy-current couplings and electronic speed controls. Drives of ¼, 1/3 and ½-hp at 1600 rpm and with 10:1 constant torque speed range and ½ and ¾-hp, 3200-rpm units with 20:1 range are available.

63. Production Stamping

Detroit Stamping Co.—Multi-stamping, or high speed production of small and intricate parts is described in 6-page folder. Wide variety of parts possible is illustrated and some of the multi-stamping machinery is pictured. Stampings range from light to medium heavy and are blanked, pierced, formed and drawn from material up to ⅜-in. thickness.

NOW

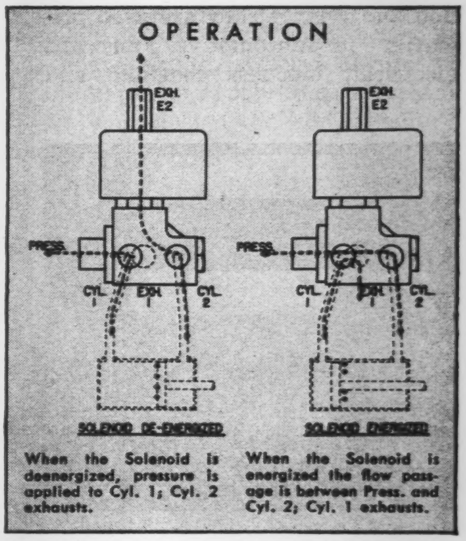
A Midget 4-WAY Solenoid Valve . . . For Controlling Small Double Acting Cylinders

Pipe Size: 1/4"
Pressures:
Maximum 125 psi
Minimum 10 psi

Fluids Handled:
Air, Water, Light Oil, Non-Corrosive Gases and Liquids

Extremely Compact to Meet Critical Space Requirements

OPERATION



SOLENOID DE-ENERGIZED

When the Solenoid is deenergized, pressure is applied to Cyl. 1; Cyl. 2 exhausts.

SOLENOID ENERGIZED

When the Solenoid is energized the flow passage is between Press. and Cyl. 2; Cyl. 1 exhausts.

FEATURING:

- **Compactness** — 4 15/32" Overall Height; 1 31/32" Width; 2" Depth; (With Standard NEMA I Solenoid Enclosures).
- **Rapid Operation** — Up to 400 cycles per minute.
- **Ruggedness** — Tested for millions of maintenance free operations.
- **Low Power Consumption** — Only 10 watts!
- **Tight Seating**—Assured by integral crown seats and resilient and nylon discs.
- **Standard, Watertight or Explosion-Proof Solenoid Enclosures available.**
- **Simplicity** — Single Operating Coil — only one electrical connection to be made.
- **Forged Brass Body** — Insures complete freedom from porosity.

NOW ASCO has available **a complete line of Midget 2, 3, & 4-Way Solenoid Valves** — an important addition to the thousands of types and sizes in the standard ASCO line.

WRITE FOR COMPLETE INFORMATION ON "ASCO MIDGET VALVES"

We also design and manufacture Control Panels to provide "Single Source Responsibility" for the Complete Automatic Control. ASCO Electromagnetic Control Equipment includes Close Differential, Time Delay, and Magnetically or Mechanically Held Relays, Contactors, Automatic Transfer Switches and Remote Control Switches.

ASCO Solenoid VALVES

Automatic Switch Co.

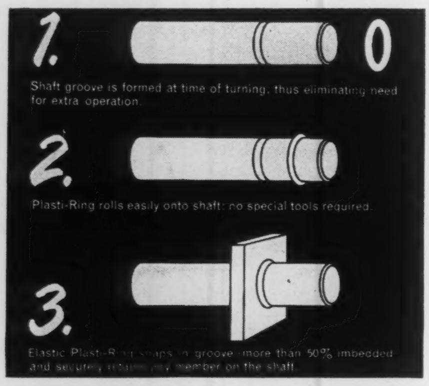
387 LAKESIDE AVENUE · ORANGE, NEW JERSEY

NEW PARTS AND MATERIALS

For additional information on these new developments, see Page 227

Plastic Shaft Retainers

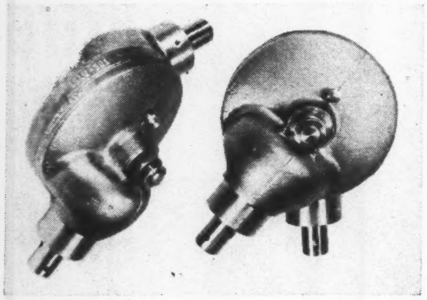
Up to 250-lb direct shear can be withstood by Shakeproof Plasti-Ring shaft retainers which are injection molded of oil and grease-resistant vinyl plastic. Rings are easily rolled into prepared groove to serve as positive-holding shoulder and are highly resistant to friction and wear. They are used primarily in automotive, aircraft, electrical, business machine and toy industries. Made by Shakeproof Div., **Illinois Tool Works,** 2501 N. Keeler Ave., Chicago 39, Ill.


1.
0
Shaft groove is formed at time of turning, thus eliminating need for extra operation.
2.
Plasti-Ring rolls easily onto shaft; no special tools required.
3.
Elastic Plasti-Ring snaps in groove (more than 50% imbedded) and securely retains any member on the shaft.

For more data circle MD-64, Page 227

Torque Transmitter

Operating at any angle, geared joint transmits torque around bends by means of a bevel gearing system. Primary application is for making sharp bends with flexible shaft or reach rod remote controls for valves. Three sizes are available to operate at maximum torque of 500, 2000 or 3500 lb-in. Corresponding flexible shaft diameters accommodated are ½ and ¾-in., 1 and 1¼ in., and 1⅝ in.; corresponding rigid rod diameters, ½ and ⅝-in., ¾ and 1 in., and 1¼ and 1½ in. Made by **Stow Mfg. Co.,** 11 Shear St., Binghamton, N. Y.



For more data circle MD-65, Page 227

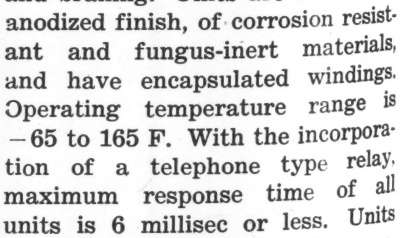
Expansion Joints

Capable of handling up to 150 psi steam at temperatures from −65 to 500 F, expansion joints are available in all pipe thread sizes from ½ to 6 in. inclusive. Spring seated wedge seal is made from Teflon and ball seats and the inside of the joint tube are chrome plated. Ball seats permit deflection or twisting of the pipe. Total permissible eccentricity is 10 deg on each end of the joint. Joints can be made of steel, stainless steel or bronze. Made by **Rotherm Engineering Corp.,** 7280 W. Devon Ave., Chicago 31, Ill.

For more data circle MD-66, Page 227

Magnetic Clutches, Brakes

Miniature single clutch, double clutch and clutch brake are used in computers and mechanisms requiring highly accurate clutching and braking. Units are made with anodized finish, of corrosion resistant and fungus-inert materials, and have encapsulated windings. Operating temperature range is −65 to 165 F. With the incorporation of a telephone type relay, maximum response time of all units is 6 millisec or less. Units are designed for 16 oz-in. maximum torque and for intermittent duty at speeds to 1000 rpm. Moment of inertia of input shaft is 0.30-oz in.^{2}; of output shaft, 0.21-

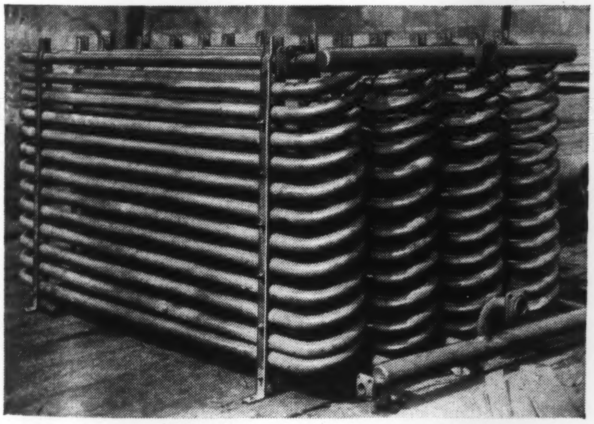


MONTREAL
ST. PAUL
CHICAGO
BIRMINGHAM
LOS ANGELES

IN 5 MODERN FABRICATING SHOPS

CRANE

builds pipe coils to DESIGN perfection



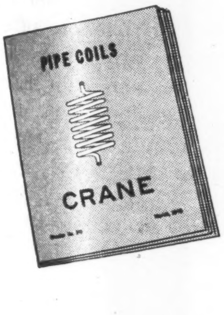
2-in. ammonia cooling coils with welded headers and ammonia flanges.

You get the results you planned for in pipe coils built by Crane. And right along with this close adherence to specification goes a greater dependability that enhances your design.

Although seamless carbon steel pipe is most popular, Crane has the experience—and the equipment to produce pipe coils in wrought iron, copper, brass, nickel, aluminum, 18-8 of various types, and miscellaneous alloys. At your service are the finest facilities for heat-treating, stress-relieving and testing of all kinds. Crane can also supply those necessary piping accessories to give your design the added value of consistent quality throughout.

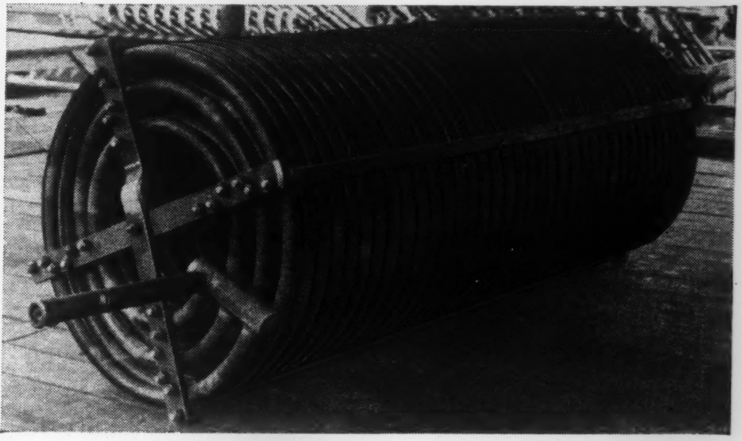
There's further information on this important Crane service in your Crane No. 53 Catalog—and in the 48-page Pipe Coil Handbook, offered below.

FREE 48-PAGE PIPE COIL HANDBOOK



Gives Valuable Design and Specification Data

Dimensions, materials, end connections, pipe data, helpful engineering information—you'll find it all in this factual, easy-to-read handbook, free to pipe coil designers and users. Drop a card to Crane at the address below for your copy (Circular 318).



Triple circular design of 1½-in. seamless pipe.

CRANE CO.

General Offices:
836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving
All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

oz-in.^{2} Input and output gears are designed to specifications. Characteristics of all units include ability to operate continuously, immediate release upon de-energizing, rapid "pull-in", and wide environmental range. A definite neutral position is provided for the friction disk. Electrical requirement is 25 v dc. Made by Ford Instrument Co., Div. of **Sperry Corp.,** 31-10 Thomson Ave., Long Island City 1, N. Y.

For more data circle MD-67, Page 227

Circuit Breakers

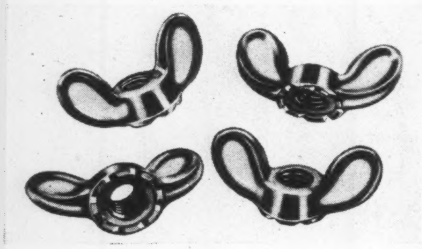
Mini-Breaker permanent circuit protectors fit branch circuits with 4, 4½, 5, 5½, 6 and 7½-amp ratings, protecting equipment rather than wiring. Used in a cut-out base wired to any motor or electrical equipment, device interrupts excessive overloads and short circuits. Built-in time lag handles temporary starting loads and line surges. Service can be restored within 10 seconds after an interruption by actuating shock-proof reset button. Trip-free, it will not maintain a circuit until the cause of the overload has been remedied. Applications include incorporation in appliances and electronic equipment. Made by **Mechanical Products Inc.,** 1800 River St., Jackson, Mich.

MINI-BREAKER
MOTOR PROTECTOR
125V MAX
A.C. ONLY
AMP
TO RESET-PUSH BUTTON ALL THE WAY IN

For more data circle MD-68, Page 227

Wing Nuts

Serrated base self-locking wing nuts are available in a complete range of standard industrial sizes. In many applications, lock washers are not needed with these nuts. They are rustproof zinc alloy and are recessed for thumb grip. In addition to a plain bright finish, all commercial finishes can be furnished. Made by **Gries Reproducer Corp.,** 400 Beechwood Ave., New Rochelle, N. Y.



For more data circle MD-69, Page 227

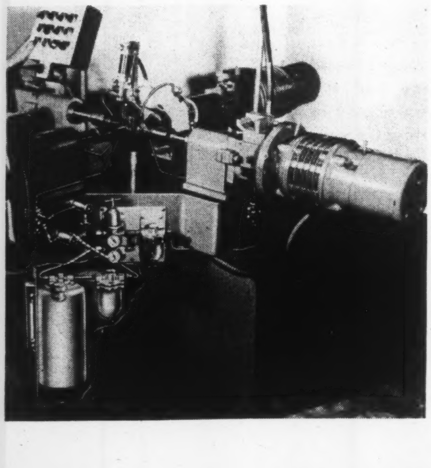
Flexible Tubing

Lightweight, flexible tubing made from General Electric's SE-100 silicone rubber compound can be bent up to 180 deg without collapsing. It withstands temperatures from −65 to 250 F and has high heat and abrasion resistance. Made by **General Electric Co.,** Waterford, N. Y.

For more data circle MD-70, Page 227

Cutting Fluid System

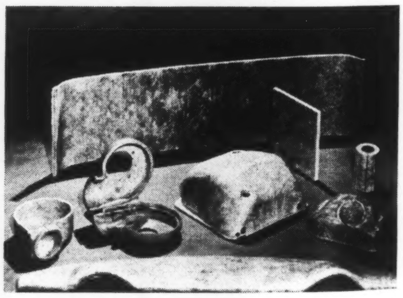
Spray-Lube system eliminates the need for a large coolant reservoir, recirculating pumps and filters in metal-cutting machinery. A 5-gal reservoir feeds coolant through tubes to the work area, where it is released in the form of a spray. Spray can be applied from any direction and to as many points as necessary to cover critical areas of contact between the cutting tools and workpiece. The finely divided oil spray distributes coolant to a large area. Individual metering control is provided at each mixing valve, and density of the spray is controlled by adjustments of air and liquid pressure regulators. Made by **C. A. Norgren Co.,** 3442 S. Elati St., Englewood, Colo.



For more data circle MD-71, Page 227

Molded Insulation

New manufacturing process makes available molded-to-shape insulation composed of resilient, plastic bonded Ultrafine glass fiber. Application of thermal or acoustical insulation or padding can be effected on an assembly line basis. Parts can be molded in any size up to 8 x 10 ft, in densities varying from 2 to 10 lb per cu ft, and thicknesses from ⅛-in. up, depending on density. Firmness and rigidity increase with density. Upper temperature limit is 350 F. Applications include use on automobiles and such appliances as television and radio sets and dishwashers. Also available is die-cut glass fiber insulation. Made by **Gustin-Bacon Mfg. Co.,** 210 West Tenth St., Kansas City, Mo.



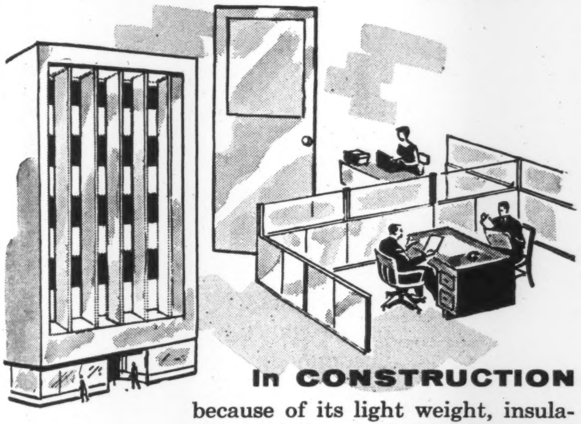
For more data circle MD-72, Page 227

Servo System Components

"Penny Size" servo system components have straight-through bore and integral stator-housing construction. Smaller of units illustrated measures ¾-in. diameter and

REYNOCELL*

THE MIRACULOUS NEW MATERIAL WITH BOUNDLESS USES

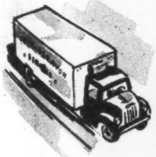


In CONSTRUCTION

because of its light weight, insulation and fire, moisture, fungi and pest resistance . . . movable partitions • folding partitions • interior curtain walls • residential doors • industrial and garage doors • solar shades • advertising signs • lean-to bomb shelters • shelving, etc.

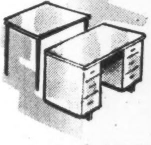
For PORTABLE EQUIPMENT

because of its light weight and structural strength . . . billboards • pallets • platforms • stage scenery • trailer and truck body parts • work stands, etc.



For INSULATED STRUCTURES

because of its excellent thermal insulation, light weight and strength . . . liners for refrigerator trucks and cars • walk-in refrigerators • refrigerated vending machines • shipping containers • oven jackets • heat baffles • preheating chambers • chicken incubators • bakery proof boxes, etc.



For FURNITURE

because of its modern beauty, light weight and fire and moisture resistance . . . desks and tables • cabinets • drafting boards • bed ends • store fixtures • portable bars, etc.

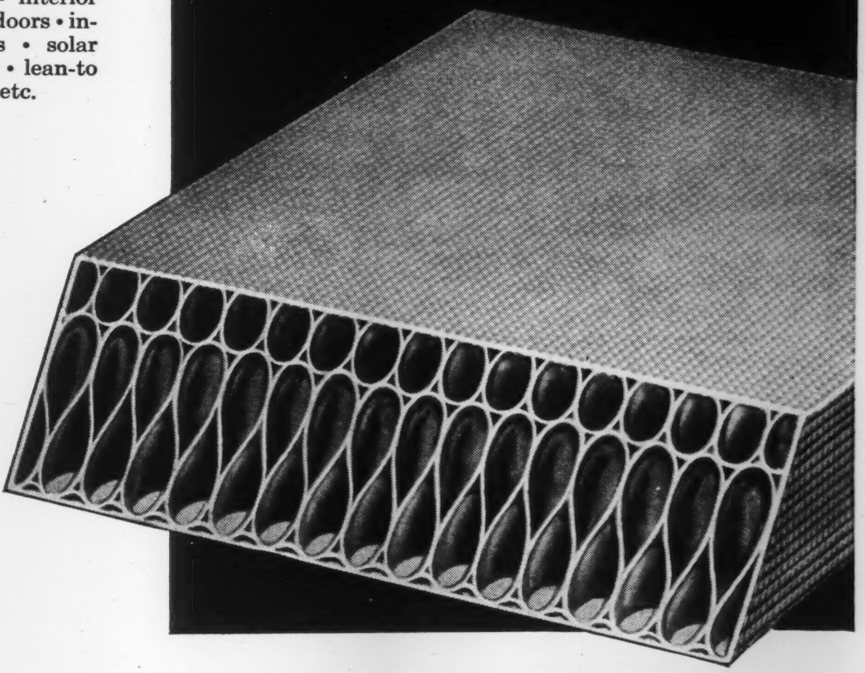
WHAT REYNOCELL IS:

Reynocell panels are extremely light, strong, rigid, prefabricated structural units. They have a honeycomb core of resin-impregnated kraft paper to which aluminum facings are securely bonded.

ITS PROPERTIES:

(Typical, based on 4″ thick panels. Comparably favorable properties apply to other thicknesses.)

Weight—1.46 lb/sq. ft.
Bending Strength—180 lb/sq. ft. of uniformly distributed load on 8′ span
Deflection—¼″ with 47 lb/sq. ft. of uniformly distributed load on 8′ span
Crushing Strength—70 psi
Thermal Insulation (U factor)—.135



REYNOLDS Engineering Service

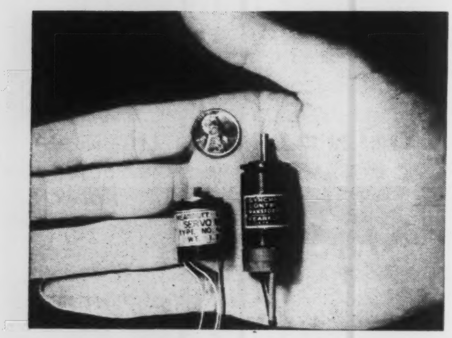
Reynolds engineers are working with a number of manufacturers on a variety of applications. Their assistance is also available to help you apply the many advantages of Reynocell Panels to your products.

Call your nearby Reynolds office listed under "Aluminum" in classified phone directories. Or write for more complete information and answers to your design questions. New applications and test data that may be helpful to you are accumulating every day. Reynolds Metals Company, 2521 So. Third Street, Louisville 1, Kentucky.

*T.M. registered

REYNOLDS ALUMINUM

MODERN DESIGN HAS ALUMINUM IN MIND

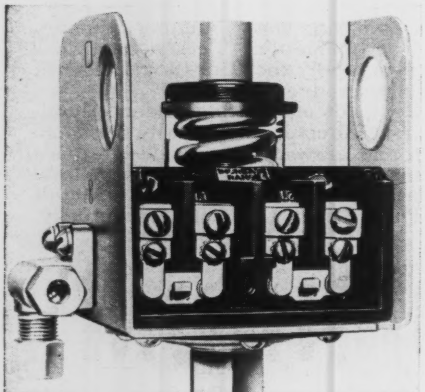


15/16-in. long. Corrosion resistance is provided by stainless steel housings, laminations and ball bearings where necessary, as well as hermetically sealed windings. No-load speed is 6500 rpm; stall torque, 0.1 oz-in. and weight, 1.2 oz. Another motor, with 4000-rpm no-load speed, is available in same size but with high inherent damping for simple instrument servos. Sensors and detectors for use with these motors measure ¾-in. diameter, 1.658-in. long and weigh 1.75 oz. They have maximum error limits of 10 minutes from electrical zero. A servo amplifier the size of a cigarette pack and precision gear trains complete line of components. Made by **Kearfott Co. Inc.**, 1378 Main Ave., Clifton, N. J.

For more data circle MD-73, Page 227

Pressure Switch

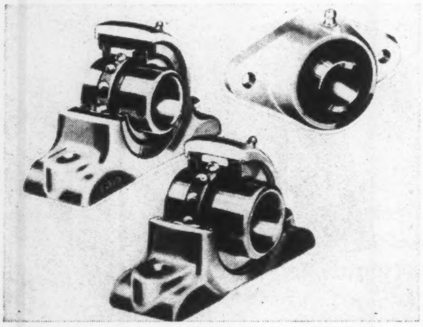
Bulletin 10007 heavy-duty pressure switch is usable where reliable long-term operation is required. Bearing surfaces are stainless steel throughout and diaphragm is nylon reinforced Neoprene. Silver alloy contacts have positive snap-action. Electrical and mechanical components are separated for ease of maintenance and trouble-free operation. Pressure type terminals are used. Openings on each side of case take ½ or ¾-in. conduit. Operating range and differential are factory set to specifications, but can be adjusted in the field. Steel case and cover are internally braced to prevent damage from abuse. Made by **Cutler-Hammer Inc.**, 328 N. Twelfth St., Milwaukee 1, Wis.



For more data circle MD-74, Page 227

Pillow Blocks, Flanges

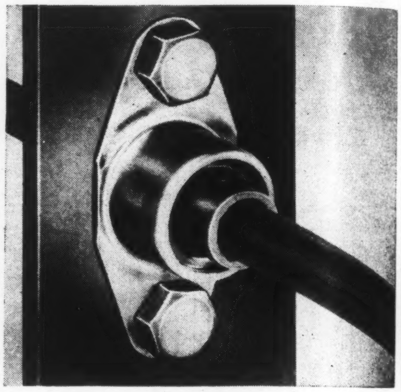
All regular and rubber insulated ball bearing pillow block and flange mountings in the ED series are now equipped with double setscrews for permanent shaft locking. Additional improvement is a standard gun type of lubricant fitting. Line is intended for light duty application and includes the ED pillow block, FED flange and EDR rubber-insulated pillow block with rubber mounting. Made by **Ahlberg Bearing Co.**, 3025 W. 47th St., Chicago 32, Ill.



For more data circle MD-75, Page 227

Radial Bearings

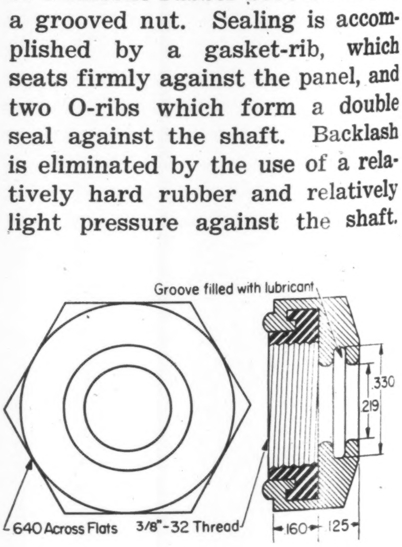
Series 6900 flange-mounted radial bearings are suitable for medium loads and speeds up to 5000 rpm. Available in standard shaft sizes ranging from ¼ to 1 in., they consist of a double composition sealed precision radial bearing and flanged housing, or adaptor, designed for flush mounting. Two locking setscrews position bearing on the shaft. Bearings, which can accommodate a limited amount of angular misalignment, are also available unground for noncritical applications. Made by **Nice Ball Bearing Co.**, 2925 Hunting Park Ave., Philadelphia 40, Pa.



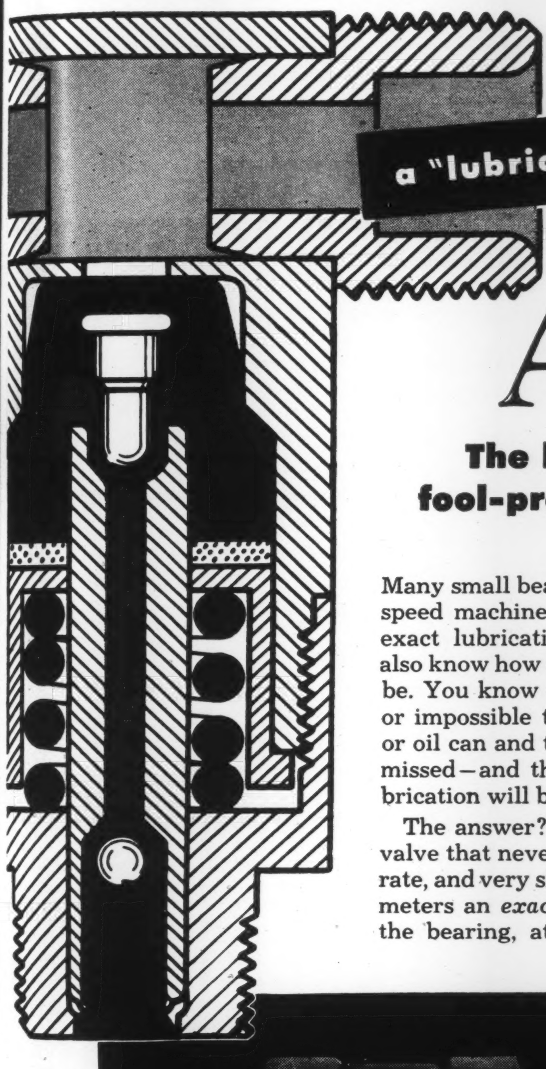
For more data circle MD-76, Page 227

Hermetic Seals

Designed for shafts which pass through panels or housings and for rotary switches, Hexseal 9000 series hermetic seals replace mounting nuts in front of the panel and seal out moisture, dust and combustible vapors. Seal consists of a silicone rubber boot molded to a grooved nut. Sealing is accomplished by a gasket-rib, which seats firmly against the panel, and two O-ribs which form a double seal against the shaft. Backlash is eliminated by the use of a relatively hard rubber and relatively light pressure against the shaft. The well between the two O-ribs is prelubricated, which enables the seal to function at intermittent speeds up to 1000 rpm. The sili-



(*Continued on Page* 240)



a "lubrication fitting" that out-thinks a man...

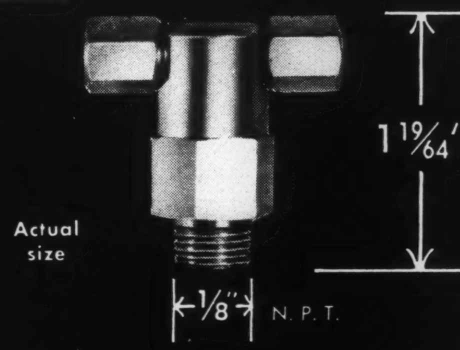
ALEMITE Accumeter®

The low-cost, simple way for you to design fool-proof, automatic lubrication into a machine with many small bearings

Many small bearings on a compact, high-speed machine. You know that proper, exact lubrication is essential, but you also know how crowded the bearings will be. You know that they will be difficult or impossible to reach with grease gun or oil can and that some of them will be missed—and the shutdown time for lubrication will be costly.

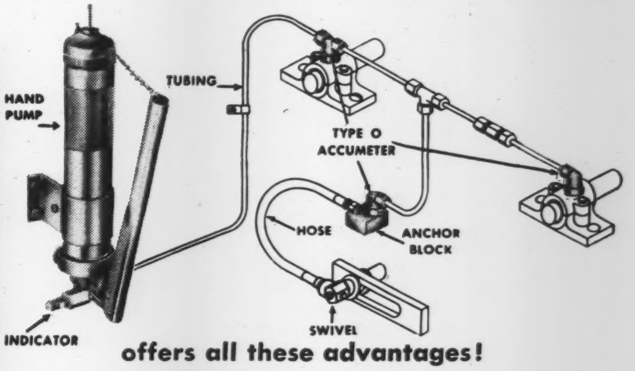
The answer? Alemite Accumeter, the valve that never forgets. This tiny, accurate, and very simple valve automatically meters an *exact* amount of lubricant to the bearing, at exactly the right time, *while the machine is in operation!* Time, maintenance and production costs drop—output soars! That's the reason that better than 95% of all major plants buying machine tools specify centralized lubrication.

Alemite Accumeter Systems are simple and economical to design into any machine—and there is a system perfect for any machine lubrication problem. Find out about these automatic systems now. See for yourself the savings and efficiency they bring to your designs and you too will specify automatic Accumeter.



Type O Accumeter Valves

Meters .005 cubic inch of oil to rotary, oscillating, stationary—plain or anti-friction bearings. Up to 200 small bearings can be served by the single-line system equipped with these fixed output valves. Requires only $\frac{9}{16}$″ approximate turning radius.



offers all these advantages!

- Eliminates shutdown time for lubrication. Adds productive time to machine output
- Seals completely against dirt, grit, water all the way from "Barrel-to-bearing"
- Prevents bearing troubles due to neglect or use of wrong lubricant
- Services all bearings—including those inaccessible or dangerous—in one operation
- Avoids work spoilage and bearing repairs due to over-lubrication

factory tested—field proved

Exhaustive, in-the-field tests show no appreciable variation in the amount of lubricant discharged after 73,312 lubrication cycles—*equal to* 122 YEARS *of twice-a-day service!*

ALEMITE
REG. U. S. PAT. OFF.

A PRODUCT OF SW STEWART WARNER

Free—*Alemite Accumeter Catalogue*

ALEMITE Accumeter

ALEMITE, DEPT. R-94
1850 Diversey Parkway, Chicago 14, Illinois
Please send me my free copy of the Alemite Accumeter Catalogue

Name______________________________

Company____________________________

Address_____________________________

City____________________State__________

ANNOUNCING

Second Conference On Mechanisms

cosponsored by Purdue University, Machine Design, and Automation

OCTOBER 11-12, 1954 **PURDUE UNIVERSITY**
Lafayette, Indiana

To promote better understanding, design and application of mechanisms in automatic machinery, MACHINE DESIGN, AUTOMATION and the Mechanical Engineering School of Purdue University have collaborated in bringing together a group of authorities on the most recent developments in this important field of design.

All machine designers and other engineering personnel interested in the design and development of mechanisms are cordially invited. For registration details see the special postcard opposite Page 210 in this issue.

Conference Committee:

- W. R. SPILLER, *Vice President of Eng., Harris Seybold Co.*
- W. A. WITHAM, *Executive Eng., Miehle Printing Press & Mfg. Co.*
- M. S. CURTIS, *Vice President of Eng., Warner and Swasey Co.*
- W. A. PATZER, *President and Chief Engineer, ABT Mfg. Co.*
- T. A. MCGILL, *Barkley & Dexter*
- B. A. SCHWARZ, *Chief Engineer, Delco Radio Div., GM Corp.*
- C. G. BIGELOW, *Asst. Mgr., Gen. Eng. Lab., American Machine & Foundry Co.*
- E. S. AULT, *Professor of Machine Design, Purdue University*
- A. S. HALL, *Professor of Mechanical Eng., Purdue University*
- M. M. MCCLURE, *Div. of Adult Ed., Purdue University*
- R. W. BOLZ, *Editor,* AUTOMATION
- B. L. HUMMEL, *Associate Editor,* MACHINE DESIGN

PROGRAM

Session 1—Special Gearing

Beveloid Gearing
A. S. BEAM, *Vinco Corp.*

Session 2—Mechanism Performance Analysis

Calculating Dynamic Characteristics of Mechanisms
B. E. QUINN, *Professor, Mechanical Engineering, Purdue*

Predicting Performance of High-Speed Mechanisms
G. A. NOTHMANN, *Armour Research Foundation*

Analysis of Mechanisms with High-Speed Photography
E. A. EDWARDS, *Eastman Kodak Co.*

Panel Group Discussions

What is Mechanism Synthesis?
Chairman, A. S. HALL, *Prof., Mechanical Engineering, Purdue*

Mechanism Manufacturing Tolerances—How Good?
Chairman, P. T. EISELE, *Warner & Swasey Co.*

Session 3—Cam Design Problems

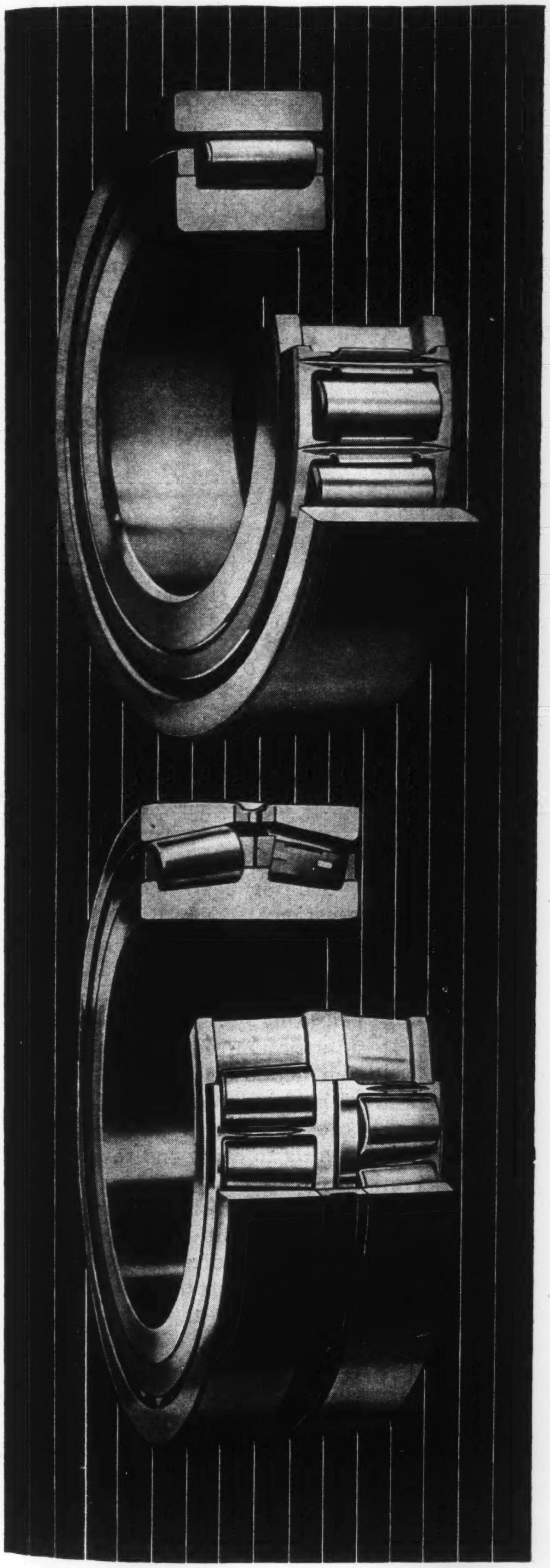
Cam Design and Manufacture
P. MAKER, *Bryant Chucking Grinder Co.*

Vibration Analysis of Cams
C. N. NEKLUTIN, *Universal Match Co.*

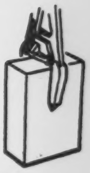
Session 4—Control Mechanisms

Straight-line Mechanisms
W. R. KEARNEY *and* M. G. WRIGHT, *Delco Radio Div., General Motors Corp.*

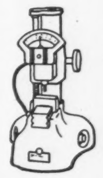
Proportional Control Mechanism
G. H. GICZEWSKI, *Bowser Inc.*



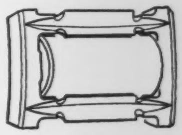
Here's how
TORRINGTON
Cylindrical and Tapered Roller Bearings
...Cut your costs, increase efficiency



Finest bearing-quality steels purchased to our specifications, plus modern heat-treating methods, insure highest load-carrying capacity, long life, and resistance to wear.

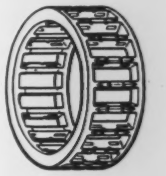


Precision tolerances and finishes on both rollers and races assure low eccentricity and uniform load distribution, cut friction to a minimum.

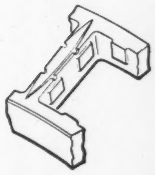


Individual roller retainment keeps rollers well lubricated, simplifies inspection of race surfaces.

Stabilized races maintain accuracy of fit under severest operating conditions.



One-piece cast-bronze cages help minimize wear, lengthen bearing life.



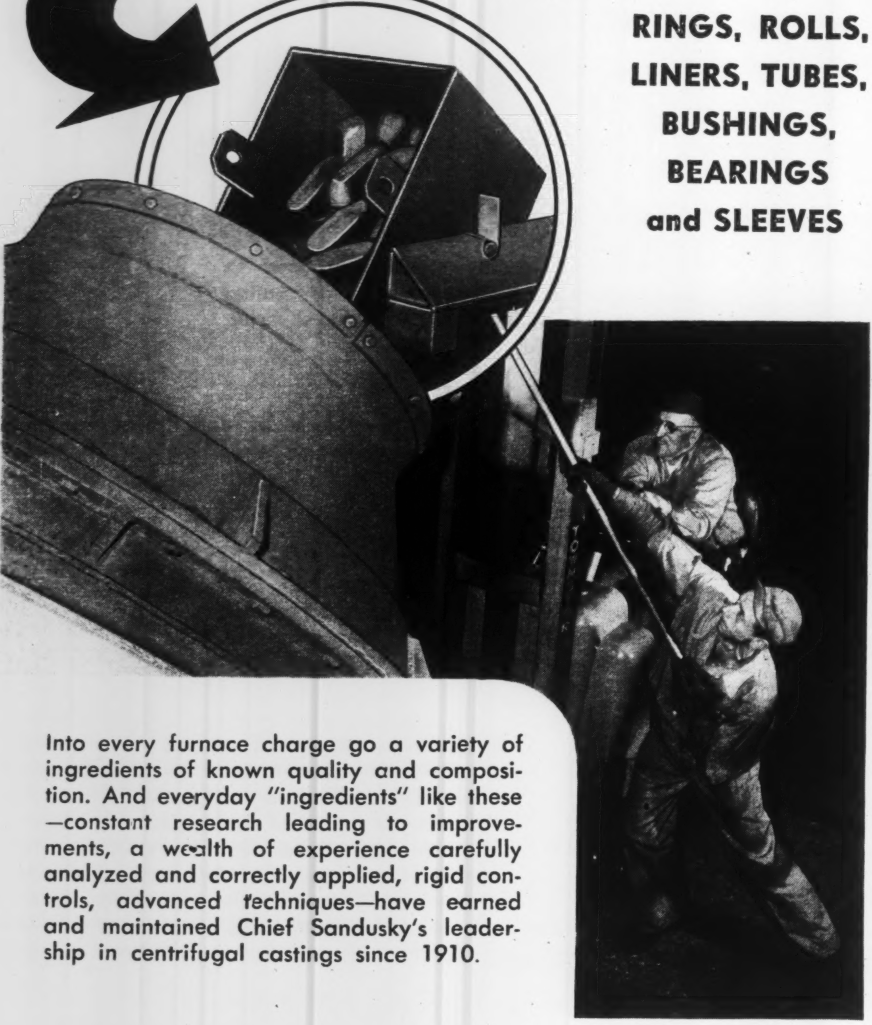
Rollers accurately guided at the pitchline—by contacting machined pads on each pocket face.

Custom engineered to meet your load and speed requirements, TORRINGTON Cylindrical and Tapered Roller Bearings increase operating efficiency in the toughest heavy-duty applications. Interchangeable in all types and sizes.
SPECIFY TORRINGTON!

THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.

TORRINGTON BEARINGS

Spherical Roller • Tapered Roller • Cylindrical Roller • Needle • Ball • Needle Rollers



THERE'S MORE TO THIS THAN MEETS THE EYE

CHIEF SANDUSKY CENTRIFUGALLY CAST

RINGS, ROLLS, LINERS, TUBES, BUSHINGS, BEARINGS and SLEEVES

Into every furnace charge go a variety of ingredients of known quality and composition. And everyday "ingredients" like these—constant research leading to improvements, a wealth of experience carefully analyzed and correctly applied, rigid controls, advanced techniques—have earned and maintained Chief Sandusky's leadership in centrifugal castings since 1910.

Chief Sandusky takes pride in offering unequalled service to users of cylindrical castings. Research specialists inside the company and on assignment welcome the opportunity to solve difficult metallurgical problems in this field—and to come up with the right, the practical answers.

The best in centrifugal castings bears the name, "Chief Sandusky."

C. M. LOVSTED & CO., SEATTLE, WASH. • TYNE BROS., BIRMINGHAM, ALA. • CORDES BROS., SAN FRANCISCO AND LONG BEACH, CALIF.

SANDUSKY FOUNDRY and MACHINE CO.

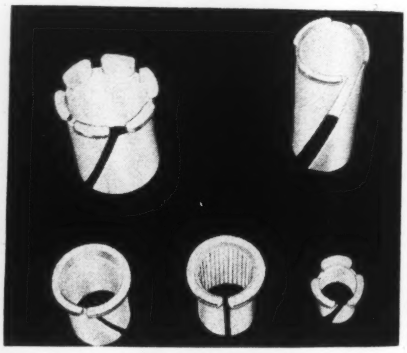
615 W. Market Street Sandusky, Ohio

(*Continued from Page 236*)

cone rubber will withstand temperatures from −67 to 500 F. Series 9000 L.T. seals function at temperatures as low as −110 F. Standard models fit ¼-in. shafts and a ⅜-in.-32 threaded bushing; other sizes and bushing threads are available. Made by **Automatic & Precision Mfg. Co.**, 252 Hawthorne Ave., Yonkers 5, N. Y.

For more data circle MD-77, Page 227

Flanged Nylon Bearings

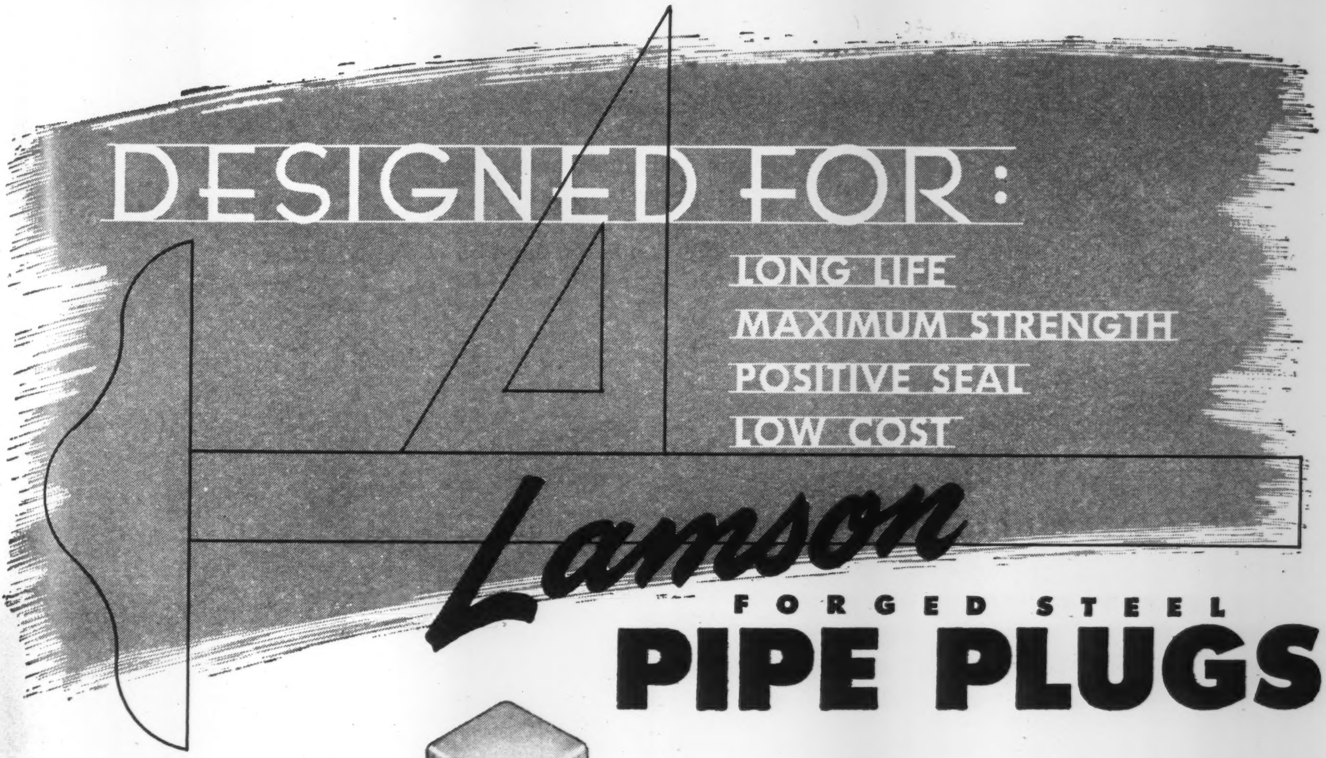


Offering corrosion and abrasion resistance, vibration damping, compactness and long life, Nyliner bearings eliminate need for lubrication. They incorporate the compensating gap principle, which permits circumferential expansion and contraction of the nylon material without appreciably affecting the bore diameter. Flange permits the bearing to carry end thrust against a shoulder in addition to radial loads and affords a simple means of axial retention of the bearing in one or both directions. A continuous flange interrupted only at the compensation gap can be provided for relatively heavy thrust loads. Either type of bearing can be provided with an antirotation boss or lug under the flange which engages a notch or slot in the bearing housing. Made by **Thomson Industries Inc.**, Manhasset, L. I., N. Y.

For more data circle MD-78, Page 227

Miniature Connectors

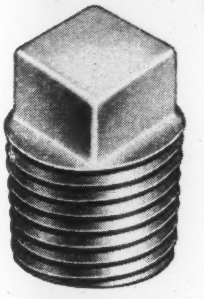
Two series of rack, panel and chassis connectors have corner-keying design which aids polariza-

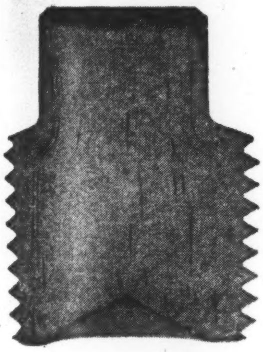


DESIGNED FOR:

LONG LIFE
MAXIMUM STRENGTH
POSITIVE SEAL
LOW COST

Lamson FORGED STEEL PIPE PLUGS





Lamson Pipe Plugs are available in the following sizes: 1/8", 1/4", 3/8", 1/2" and 3/4".

Have you checked the Pipe Plugs you are using lately? Like so many common but important parts to your product, Pipe Plugs are apt to be taken for granted with a resultant loss in production time and efficiency.

Lamson Pipe Plugs are FORGED for maximum strength and positive sealing. Heads will not chip or break under severe wrenching. This means savings for you on the production line. The ROLLED "DRYSEAL" THREADS of Lamson Pipe Plugs guarantee maximum toughness and correct tolerances are assured by Lamson's famous "Quality Control" system.

Yet, despite the extra protection and value Lamson Pipe Plugs offer, they cost no more than other types. You get true premium quality at a low "regular" price.

So next time specify Lamson Pipe Plugs—in steel, brass, bronze or aluminum—and give your product the extra advantage it deserves.

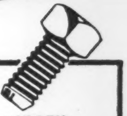
Lamson + Sessions

The LAMSON & SESSIONS Co.
1971 West 85th St. • Cleveland 2, Ohio
Plants at Cleveland and Kent, Ohio • Birmingham • Chicago

FOR PROMPT DELIVERY AND HELPFUL SERVICE, ORDER FROM YOUR LAMSON DISTRIBUTOR

PLUG NUTS
Ideal for blind or hard-to-reach places.

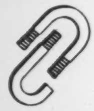
PIPE PLUGS
Forged steel, heat-treated.



"1035" SET SCREWS
Cup point type, hardened and heat-treated.

PLACE BOLTS
With "Built-in" spring action for positive locking.

LOCK NUTS
Economical, vibration proof. Can be used repeatedly.



"BENT BOLTS"
Including U bolts, eye bolts, hook bolts, etc.

MACHINE SCREWS
Clutch and Phillips recessed head screws.

SEMS
Pre-assembled lockwashers on tapping and machine screws.

Seal it!

ITH S. S. WHI

PLASTIC CLOSURES

- For threaded and unthreaded parts and openings.
- Easy to apply—easy to remove. Once on—*they stay put.*
- Use them to—
  - —Seal out dirt, moisture and dust
  - —Seal in fluids and lubrication
  - —Protect threads
- Immediate deliveries of a wide range of standard sizes.

PLAIN ELASTOPLASTIC PLUGS AND CAPS

Seal flush to permit easy stacking of parts. Unaffected by oil, grease or gasoline. Made of tough, rubberlike plastic.

THREADED PLASTIC PLUGS AND CAPS

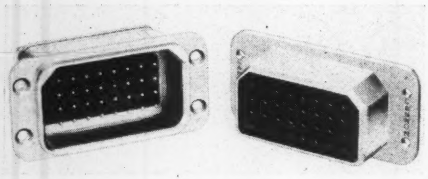
Cleanly molded threads assure easy application. Provide safe, sure positive protection to threaded parts. Unaffected by most petroleum base products.

GET THE DETAILS

Bulletins P-5312 and P-5203 have full details on sizes and types available. Write for your copies. Dept. 4P.

THE S.S.White PLASTICS DIVISION
DENTAL MFG. CO.
10 EAST 40th ST. NEW YORK 16, N. Y.
Western District Office • Times Building, Long Beach, Calif.

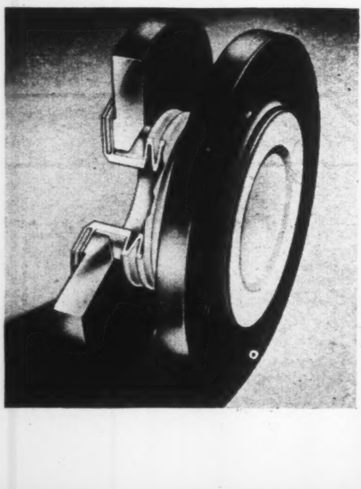
tion. Type DPA measures 2 x 1 x 23/32-in.; type DPX, 2 5/16 x 1⅛ x 1⅛ in. Straight and angle 90-deg junction shells with integral clamps are available for DPA type. Contact arrangements available include standard 5 and 10 amp and 5-amp coaxials up to a total of 32 contacts. Two DPA and seven DPX layouts are available. Insulation materials are melamine or Diall 51-01, both of which have high dielectric strength. Shells are die-cast aluminum alloy, and contacts are gold-plated brass or bronze. Made by **Cannon Electric Co.**, 3209 Humboldt St., Los Angeles 31, Calif.



For more data circle MD-79, Page 227

Plastic Bellows

Chemically inert, corrosion and heat-resistant Teflon bellows are available with companion flanges conforming to American Standard bolt hole circles and numbers for pressures up to 125 psi. Pipe size range is ½ to 12 in. Operating temperature range is −94 to 500 F. Use of new convolution form results in good strength and flexibility and long life. Bellows expand and contract in either direction with equal freedom of motion. Typical applications include vibra-



HERE'S WHAT *We* MEAN BY—

Miniature

BEARINGS!

TYPE RF

FILMOSEAL

from 0.1969" O.D.

Smallest Sealed Retainer Type Radial Ball Bearing

An RMB First

This is a miniature bearing! It looks like a big bearing, doesn't it? That's because it has all the features of a big bearing, such as—

- Deep groove races
- Balanced two-piece or snap-type ball retainer
- Non-rubbing capillary oil seal
- Removable and replaceable dust shield
- Precision tolerances

RMB Type RF Filmoseal bearings (illustrated) are available in sizes from 0.1969" O.D.

Type RF now available in R2 size (ABEC-1, 3, 5) (⅛" bore—⅜" O.D.)

Bring your Miniature Bearing Problems to RMB

A complete line of over 250 miniature and instrument bearings including radial and roller types available for prompt delivery. Experimental quantities from stock.

Write for catalog 12
Or see our catalog in Sweet's Files.

RMB LANDIS & GYR,
INCORPORATED
45 WEST 45TH ST. • NEW YORK 36, N. Y.

JALTEN No1
JALTEN No2
JALTEN No3
Give your order...
THEY'RE ALL JALTEN!

J&L's New JALTEN series enables you to select low-alloy, high-strength steel in the following combinations of advantages:

[illegible] High strength, good formability and fabricating—good resistance to low temperature impact.

[illegible] High strength, moderate forming—improved resistance to atmospheric corrosion.

[illegible] High strength—improved resistance to abrasion.

Remember to specify JALTEN High Tensile Steel for

- HIGH STRENGTH • RESISTANCE TO CORROSION
- GOOD FORMABILITY • RESISTANCE TO ABRASION

Jones & Laughlin
STEEL CORPORATION — *Pittsburgh*

Make your products stronger, lighter, longer lasting
Jalten
LOW-ALLOY
HIGH-STRENGTH STEEL
J&L STEEL
JONES & LAUGHLIN STEEL CORPORATION

The data you want is in this book:

- Chemical Properties of Jalten
- Mechanical Properties of Jalten
- Jalten Equivalents
- Jalten Application Data

Jones & Laughlin Steel Corporation
Dept. 410, 3 Gateway Center, Pittsburgh 30, Pa.

Please forward a copy of your booklet, Jalten low-alloy, high-strength steel.

Name____________________

Company____________________

Address____________________

engineers and PA's

This useful fact-filled catalog

NEW!
CURTIS UNIVERSAL JOINT CO. INC.

YOURS FOR THE ASKING

Everything you need to know about

CURTIS UNIVERSAL JOINTS

in one convenient, file-size package.

Partial list of contents

- Sizes & styles
- Special joints
- How to specify
- Test data
- Torque & load ratings
- Keyway & Broach data
- Dimension drawings
- Engineering data
- Prices

Write today on your letterhead for your FREE copy.

TRADE MARK **CURTIS**

UNIVERSAL JOINT CO., INC.

5 BIRNIE AVENUE, SPRINGFIELD 7, MASS.

As near to you as your telephone

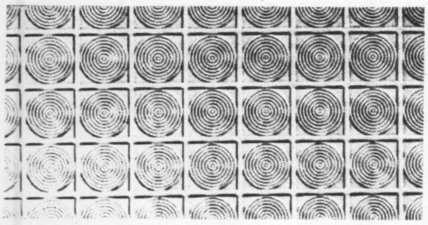
SINCE 1919 — EXCLUSIVELY
A MANUFACTURER OF UNIVERSAL JOINTS

tion dampers, expansion joints and connectors. Bellows are available in wide range of designs for pumps, accumulators, batching scales, hydraulic systems and other installations. Made by **Crane Packing Co.**, 1800 Cuyler Ave., Chicago 13, Ill.

For more data circle MD-80, Page 227

Patterned Metal

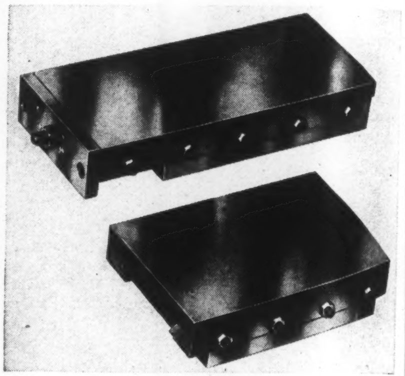
Designed for decorative uses, C-i-S pattern of Rigid-Tex metal consists of concentric circles within squares. Pattern effectively conceals fingerprints, scratches and smudges and controls light diffusion to eliminate glare. It imparts strengthening effect to light gage metal which is furnished in sheet, strip and coil form in a variety of finishes, including two-tone effects, electropolished and painted finishes. Pattern has 7¾-in. maximum width and a maximum thickness of 0.025-in. with maximum pattern depth of 0.005-in. in type 302 annealed stainless steel. Maximum thickness specification will vary with type and temper of metal required. Made by **Rigidized Metals Corp.**, 693 Ohio St., Buffalo 3, N. Y.



For more data circle MD-81, Page 227

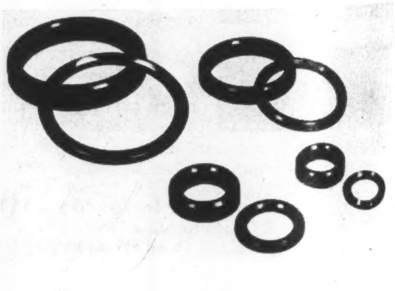
Slide Assemblies

Fifty-two types and sizes of standard slide assemblies are available in 2 to 6-in. widths, 3 to 16-in. lengths and with travel ranging from ¾-in. to 4 in. Slides move on dovetail ways. Male and female members, of wear-resistant, high tensile strength iron, are treated to eliminate distortion. Top and bottom surfaces of both members are precision machined and ground parallel. Gibs with adjusting screws are provided for regulating the clearance and compensating for wear as required. Basic slides include male and female members, gib and gib adjusting screws. Assembled slides, identical in design and dimensions, also have compression type return springs, mounted on guide pins in an end plate and fitting into drilled holes in the male member; adjustable stop screw for regulating length of slide travel; oil-resistant Neoprene shield to protect sliding surfaces; and two drilled and countersunk holes in male member to receive mounting screws. Both types are available with either machined or hand-scraped sliding surfaces. Made by **Russell T. Gilman Inc.**, 2410 N. Farwell Ave., Milwaukee 11, Wis.



For more data circle MD-82, Page 227

Homogeneous V-Rings



Homogeneous V-rings molded to JIC accepted dimensional standards are for use in hydraulic and pneumatic applications at pressures to 5000 psi. Rings are of-

(*Continued on Page* 249)

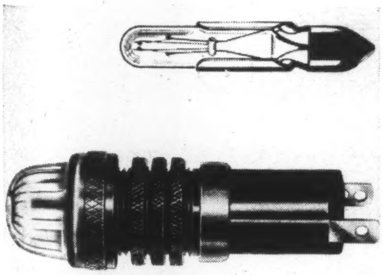
(*Continued from Page* 244)

fered in two types of synthetic rubber. No. 1225 Neoprene-base compound is fabricated into rings having low friction, low swelling and high wear resisting characteristics. Rings made with No. 1275 Buna-N base compound have high oil resistance, low friction and high wear-resisting characteristics. Use of impregnated fabric adapters is recommended to support the V-rings and to resist extrusion and minimize failure. Made by Packing Div., **Raybestos-Manhattan Inc.,** Manheim, Pa.

For more data circle MD-83, Page 227

Indicator Lights

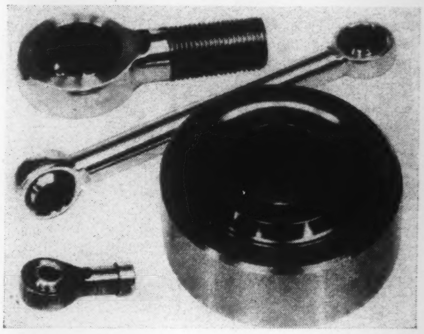
Series of pilot light assemblies is designed to employ telephone type incandescent bulbs having a slide base. Lamps can be replaced without tools. Screw or friction fitted caps have flat or convex lenses of ⅜ or ½-in. diameter. Wide angle visibility cap is also available. Back projection is kept to minimum for easy mounting in shallow panels. Mounting requirement is a single 9/16-in. hole; adjacent units can be placed as close as ¾-in. center-to-center. Solder or screw terminals are available. Made by **Dialight Corp.,** 60 Stewart Ave., Brooklyn 37, N. Y.



For more data circle MD-84, Page 227

Spherical Bearing

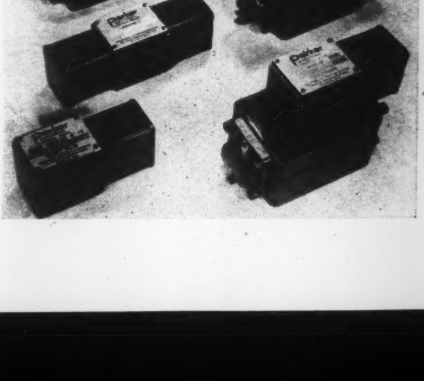
Spherical bearing can be constructed in wide range of materials and has selective and close-tolerance fit between race and ball. Large bearing area allows heavy radial and axial loads, and assemblies are suitable for use in high temperature applications. Heavy load applications are possible, such as mounting jet engines in aircraft. Bearing is available in many configurations including rod ends, and in sizes up to No. 16. Other sizes can be produced as required. Made by **Delron Co. Inc.,** Bearing Div., 5224 Southern Ave., South Gate. Calif.

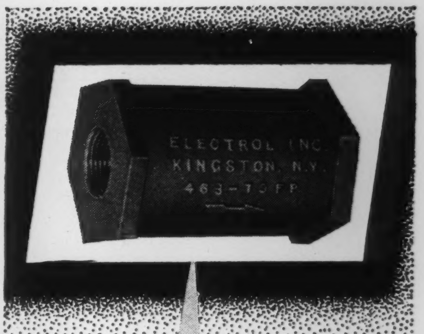


For more data circle MD-85, Page 227

Hydraulic Control Valves

Five directional control valves for gasket type mounting are designed for use in hydraulic systems with operating pressures up to 2000 psi. All models conform to JIC specifications. Valves are pilot-operated; single or double solenoid-operated; or single or double solenoid-controlled, pilot-operated. Solenoid-operated valves are rated at 3 gpm maximum capacity. Either of two subplates or equivalent mounting pad may be used. One subplate, for flows to 1 gpm, has ¼-in. pipe threads; the other, for flows to 3 gpm, has ⅜-in. pipe threads. Pilot-operated as well as solenoid-controlled, pilot-operated valves are rated at





Electrol
Check Valves

Prevent Reversal of Flow in AIR . . . OIL OR WATER APPLICATIONS

Electrol (463FP) Check Valves are ideally suited for heavy-duty service applications—providing positive sealing against return flow in air . . . oil . . . or water control lines, with a minimum of pressure drop. They have a maximum operating pressure of 5,000 P. S. I., with a cracking pressure — in free flow direction —from 2 to 8 P. S. I. Elements are of brass and bronze — and include an O-ring check seat. Sizes range from ⅛" to 2" N.P.T. Your inquiries will receive prompt attention.

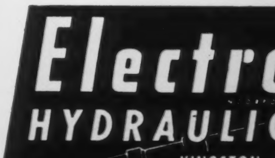
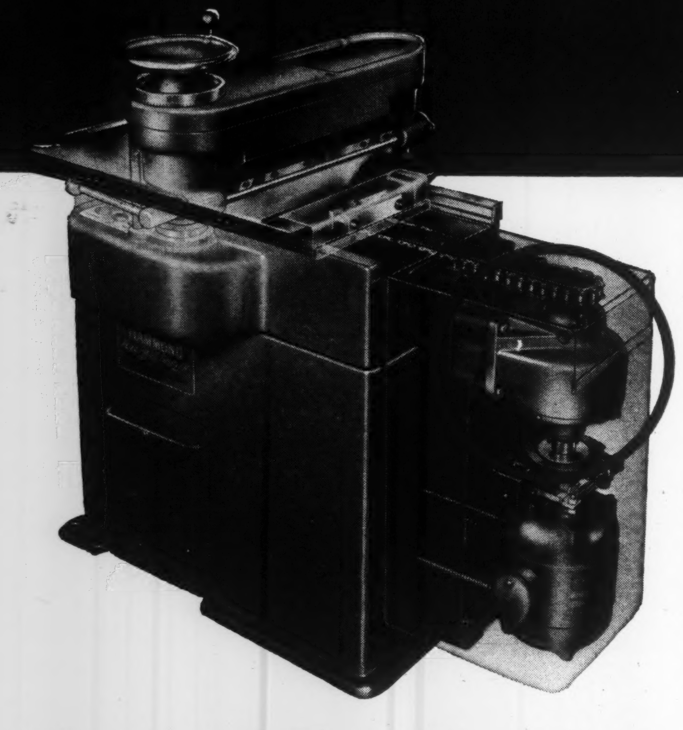


Diagram showing internal construction of the Electrol (463FP) Check Valve.

Better Designed Products Use Electrol Hydraulics

Electrol
HYDRAULICS
KINGSTON, NEW YORK
Telephone, Kingston 1980

CYLINDERS • SELECTOR VALVES • FOLLOW-UP VALVES CHECK VALVES • RELIEF VALVES • HAND PUMPS POWERPAKS • LANDING GEAR OLEOS • SOLENOID VALVES • ON-OFF VALVES • SERVO CYLINDERS • TRANSFER VALVES • CUT-OUT VALVES • SPEED CONTROL VALVES



Shaving newspaper plates ... quickly, accurately

Hammond Plate Shavers use

WINSMITH SPEED REDUCERS

Shaving 19" x 26" newspaper plates to correct printing height within 12 seconds ... shaving 30 to 40 thumb nail shell plates at one time with uniform accuracy, this Hammond Model S-8 Plate Shaver is equipped to help a newspaper go to press before deadline.

Directly coupled to a 1½ HP motor in the drive mechanism, which moves the plates into the carbide blade, is a Winsmith Model 11H Differential Speed Reducer with a reduction ratio of 108:1. Correct speed for fast, smooth and accurate shaving is assured.

Compactness, ruggedness and dependability have made Winsmith reducers most preferred for applications within the 1/100 to 85 HP range, in ratios of 1.1:1 to 50,000:1. Why not find out how this complete line of differential, worm gear, helical gear and worm-helical reducers can meet your needs to best advantage?

For details, request Catalog 148 ... and for information on Winsmith's new "C" Line Worm Gear Speed Reducers, request Bulletin HW654.

WINSMITH, INC.
16 Elton St.
SPRINGVILLE (Erie County), N. Y.

WINSMITH SPEED REDUCERS ®

MEMBER OF AGMA

22 gpm capacity. Subplate is tapped for ¾-in. pipe. Pilot pressure ranges from 50 to 2000 psi valve capacity. From one to six spool types, all of which are interchangeable in the same body, are offered in each design. Made by Industrial Hydraulics Div., **Parker Appliance Co.,** 17325 Euclid Ave., Cleveland 12, O.

For more data circle MD-86, Page 227

Motor-Driven Generator

Miniature precision ac motor-driven induction generator combines an induction motor having a high torque-to-inertia ratio with a linear drag cup generator. It provides positive alignment of motor and generator in a single housing machined to close tolerances.

When one phase of the two-phase generator is excited, the other develops an output voltage proportional to the speed. Both motor and generator operate on 115-v current. Input of motor, stalled, is 7.4 w; stalled torque is 0.8-oz-in. No-load speed of generator is 3070 rpm counterclockwise; reversing time is 0.06-sec, and moment of inertia is 7.4 gm cm². Unit weighs 15.4 oz. Made by **Electric Indicator Co. Inc.,** Springdale, Conn.

For more data circle MD-87, Page 227

Threaded Fasteners

Quintlock cadmium-plated steel fasteners provide permanent threads in sheet metal. Collar of the nut is either hammered or punched into a hole in the metal and the fastener is held against screw torque by four pronged

Cut Production Costs with REVERE ALUMINUM

Fin stock, made of Revere Aluminum Coiled Sheet, is saving time and money for leading manufacturers of convectors, baseboard convectors, unit heaters, air conditioners and refrigeration equipment—much of it in combination with Revere Copper Tube. Uniformity of properties and accuracy of gage are among the reasons for the widespread use of this fine Revere material.

Available in a number of alloys, Revere Aluminum Products include coiled sheet, extruded products, seamless tube, and forgings, as well as electrical bar. The Revere Technical Advisory Service is ready to help you use them to advantage.

Send for your free copy of the new 28-page booklet, "Revere Aluminum Extruded Products." Address Dept. ME9.

REVERE ALUMINUM

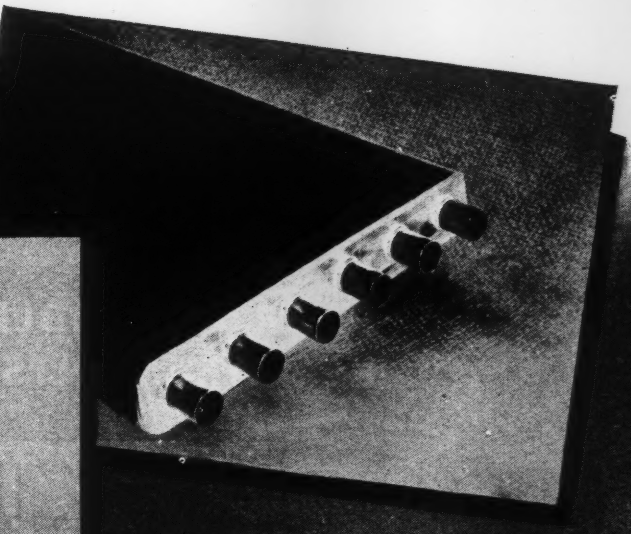
REVERE COPPER AND BRASS INCORPORATED

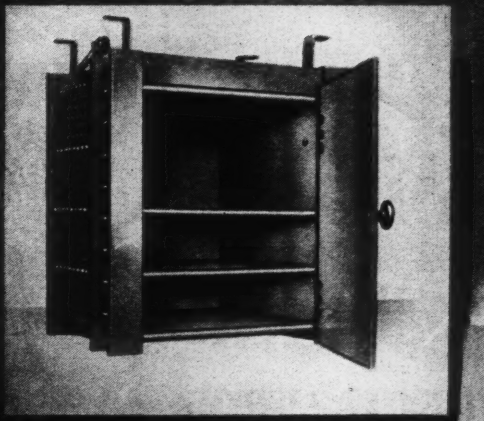
Founded by Paul Revere in 1801
230 Park Avenue, New York 17, N.Y.

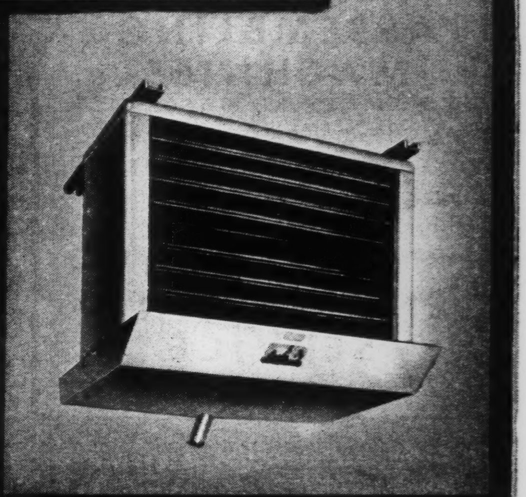
• • •

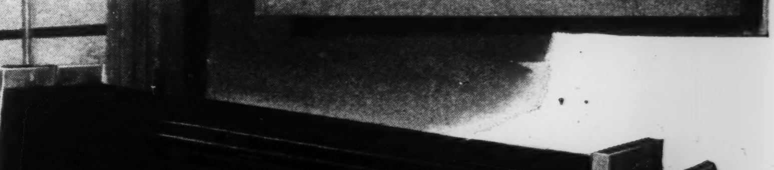
Mills: Baltimore, Md.; Chicago and Clinton, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Rome, N. Y.—Sales Offices in Principal Cities.

SEE "MEET THE PRESS" ON NBC TELEVISION, SUNDAYS









Now! Greater than Ever
FACILITIES
TO MEET YOUR ASSEMBLING REQUIREMENTS!

POWER SCREWDRIVERS

SELECTIVE PARTS FEEDERS

SPECIAL ASSEMBLING MACHINES

EXTENDED ENGINEERING SERVICE

POWER SCREWDRIVER

BARREL FEEDER

BOWL FEEDER

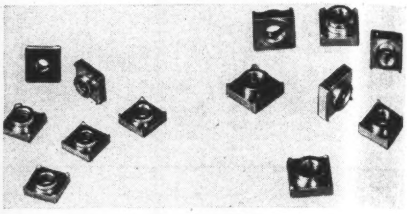
SPECIAL ASSEMBLING MACHINE

● *Action . . . More Action . . .* in your assembly department! *More Speed . . . Greater Accuracy . . . Lower Costs . . .* Vital factors in your production program . . . Advantages available to you through the DPS expanded line and increased manufacturing facilities . . . Tell us your story . . . *Let our trained engineers analyze your problem . . .* Whatever your feeding and assembling operations may be, they will come up with a practical solution.

GIVE US THE DETAILS . . . SEND SAMPLE ASSEMBLY.

DETROIT POWER SCREWDRIVER CO.

2801-A W. FORT ST. DETROIT 16, MICHIGAN



corners which imbed themselves in the surface of the sheet. The collar bites into the side of the hole to anchor it against reverse fall-out. Fasteners will resist up to 87 lb-in. of screw torque in aluminum sheet. They are available in 4-40, 6-32, 8-32, 10-32 and ¼-20 machine screw sizes with collar lengths to fit sheet thicknesses from 0.050-in. Made by **Fox Products Co.,** 4720 N. Eighteenth St., Philadelphia 41, Pa.

For more data circle MD-88, Page 227

Foot Switch

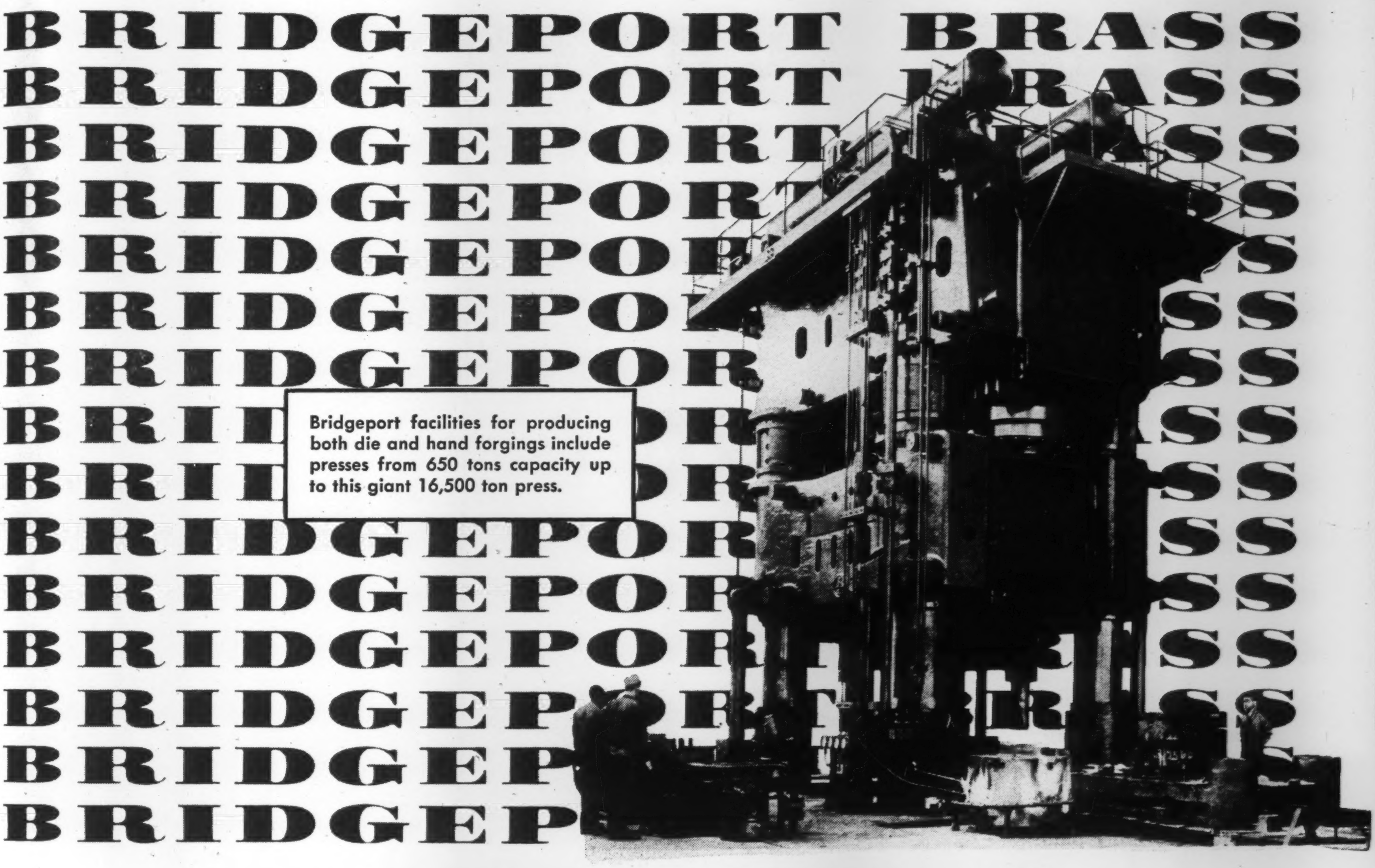
Clipper foot switch for heavy-duty operation has a black wrinkle finish cast iron housing with sponge rubber skid pad to prevent sliding. It may be operated easily from either sitting or standing positions.

Mechanism is well protected from dust but is accessible for wiring by removal of two screws. Weight is 2 lb. Made by **Linemaster Switch Corp.,** 424 Woodstock Terrace, Woodstock, Conn.

For more data circle MD-89, Page 227

Brakemotor

Utilizing the motor end bracket as an integral part of the brake results in a brakemotor of short



Bridgeport facilities for producing both die and hand forgings include presses from 650 tons capacity up to this giant 16,500 ton press.

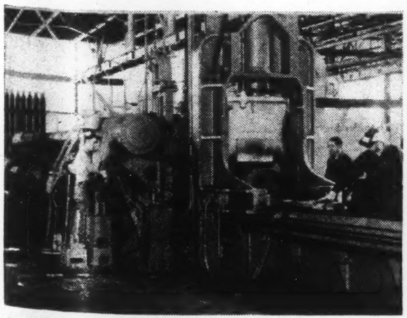
BRIDGEPORT ALUMINUM

is backed by 89 years of Superior Customer Service

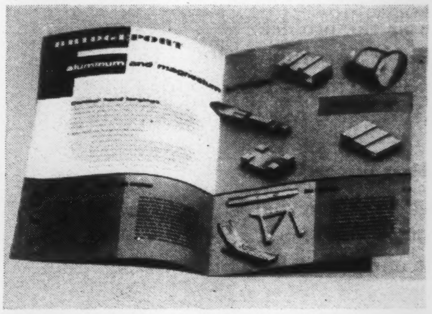
Personalized service to customers has always been an important part of Bridgeport's policy. That's why, when you discuss your aluminum requirements with a Bridgeport representative, you'll find him paying careful attention to matters like your fabricating, production and finishing problems, cost factors and your finished product . . . in short, a good deal more than just the order.

This customer service is backed by a staff of trained light-metal production specialists, which assures you of quality Bridgeport Aluminum Products—and *on-time* deliveries.

Other specialized Bridgeport services are available to you in the form of research and technical assistance—development work in titanium and magnesium—all yours to use in solving your light-metal problems. Call your local Bridgeport Sales Office for more information on Bridgeport Aluminum Products and our services.



Bridgeport's sixteen extrusion presses with capacities from 1650 tons to 5500 tons can serve your needs for Aluminum Extrusions in a wide variety of shapes and alloys.



Bridgeport Contour Hand Forgings save production and material costs on high-strength parts in limited quantities. Write for your copy of this Forging Folder.

BRIDGEPORT BRASS COMPANY
ALUMINUM DIVISION • BRIDGEPORT 2, CONN.
Sales Offices in Principal Cities—Conveniently Located Warehouses
Mills at Bridgeport, Conn., Indianapolis, Ind., and Adrian, Mich.

Bridgeport

See our exhibit at the
National Aircraft Show
September 4, 5, 6, Dayton, Ohio

BRIDGEPORT ALUMINUM

ROTH RR RUBBER
SPANKS
up to
40
TONS
AN HOUR!
PETTIBONE SPEEDPILER

Abrasion resistant rubber paddles are easily replaced in new

PETTIBONE SPEEDPILER

Whirling at 2000 feet a minute, six rubber paddles throw sand, crushed stone, coal, chemicals, feed, grain, salt, sugar, fertilizer and other bulk materials . . . wet or dry . . . 47 feet and farther. Most of this material, up to 1″ in size, has a terriffic abrasion quality.

Roth Rubber Engineers Solved This Problem

Roth engineers specified and formulated just the right rubber to resist this tremendous abrasive action. Also solved was the problem of fast, easy, inexpensive replacement. Roth engineers can solve *your* rubber problems. There's no obligation for Roth technical assistance. Write us a description of your rubber problem or your rubber requirements. We'll be glad to help.

Engineers and Rubber Buyers!

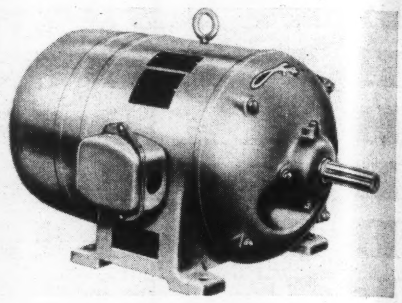
Write for your free Roth Rubber Sampler. This unusual kit contains actual rubber samples with hardness from 5 to 100 Durometer . . . gives ASTM specs and lists uses for each sample. Sorry, but offer must be limited to engineers and rubber buyers only.

Please ask for Roth Rubber Sampler No. MD1.

Custom manufacturers of Industrial Rubber Products since 1923

ROTH RUBBER COMPANY

1856 S. 54TH AVENUE • CHICAGO 50



overall length. Units are available in NEMA motor frame sizes from 203 to 326. Disk brakes furnish maximum continuous duty torque from 3 ft-lb in the smaller sizes to 50 ft-lb in the largest sizes. External wear indicator eliminates need for cover removal and constant brake-lining inspection. One torque-adjustment nut sets brake for any rating. Unit has cast iron external parts; dependable brake lever system; maximum solenoid-gap limit; and one-piece, low-inertia molded friction lining. Made by **Louis Allis Co.,** 427 E. Stewart St., Milwaukee 7, Wis.

For more data circle MD-90, Page 227

Transparent Plastic

Made from HT-CR-39 resin, transparent plastic is available in sheet form in standard thicknesses up to ½-in. Intended for flat glazing applications, it has strong impact resistance and withstands short exposure to temperatures as high as 350 F without losing clarity or rigidity. The material also offers good resistance to abrasion, hot metallic spatter and all types of chemical fumes and solvents. Made by **Cast Optics Corp.,** 1010 Post Rd., Riverside, Conn.

For more data circle MD-91, Page 227

Air Cylinders

Double-acting Studmount air cylinders have 1⅛-in. bore and are available in ½-in. increments of stroke from 1 to 6 in. Brass heads are nickel plated and screwed into honed and "Copper-brited" cylinder tube. Stainless steel piston rod is screwed and brazed to brass piston. Standard

Announcing

he NEW Louis Allis

Electronic

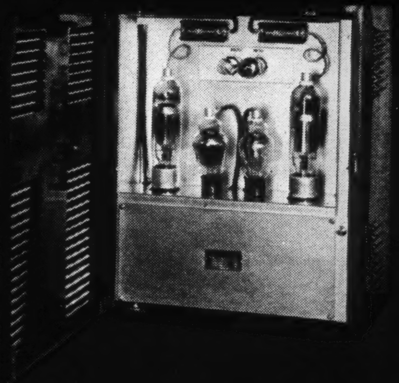
Select-A-Spede

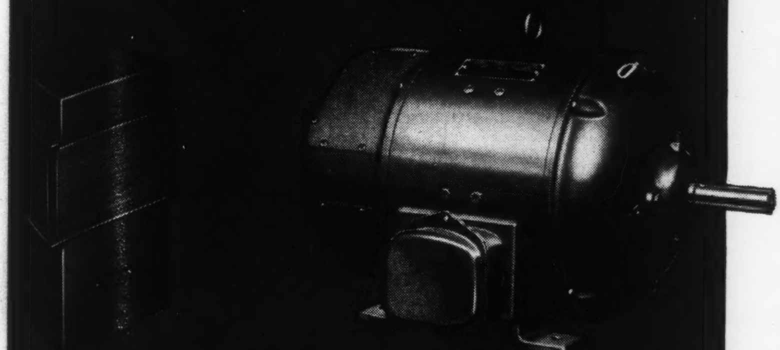
FORWARD
REVERSE
STOP

precision speed control

wide speed range

rugged, reliable construction



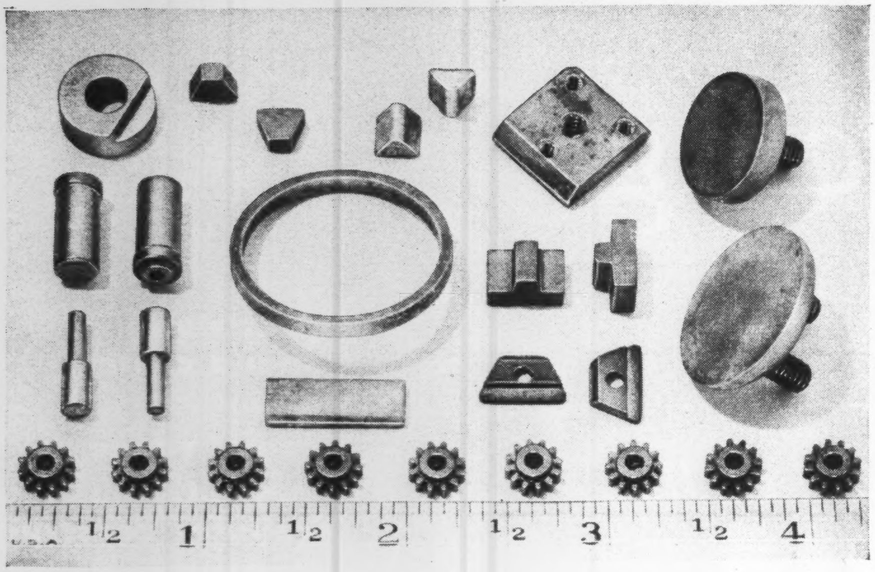


Connect this new Electronic Select-A-Spede to your A.C. power source and get infinitely adjustable speeds in ranges of 5:1, 20:1, or 50:1, with 100:1 also available for some applications. And that's not the only feature of this new variable speed drive. You get precise speed regulation — as close as ½% with tachometer feedback. You get rugged design for tough industrial service — simple, reliable, electronic circuits.

This new Electronic Select-A-Spede consists of an anode transformer, control panel, pushbutton station, and D.C. drive motor. Transformer and control can be located in almost any convenient place with motor and pushbutton station available in any enclosure you need. And you can get many electrical and mechanical modifications, as well as a variety of optional features — inching, reversing, threading, etc.

The Electronic Select-A-Spede is ideal for machine tools, test equipment, conveyors, printing presses, balancing machines — wherever high flexibility and precise speed control are needed. Get full information on this versatile new drive from Bulletin No. 1500. Ask your Louis Allis Sales Engineer for your copy or write to us.

THE LOUIS ALLIS CO.



Superior makes quantity molded mechanical parts with individual precision

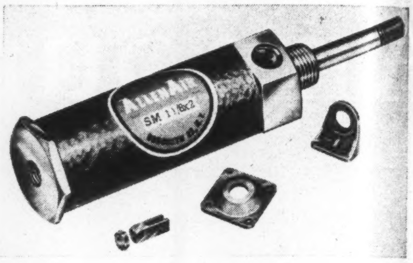
. . . for parts of iron, brass, nickel, tungsten alloys, and silver

- Why machine or cast small, intricate parts? Superior can produce quantities of accurate parts at a very low cost per piece by powder metallurgy. Every piece of a run will be uniform in size, strength and density. Superior can make alloyed metal parts to fit your application, recommending the right material for the job you have in mind. Consult Superior first.

Send us your blueprint and specifications.

SUPERIOR CARBON PRODUCTS, INC.
9115 GEORGE AVENUE • CLEVELAND 5, OHIO

SCP
SUPERIOR CARBON BRUSHES
"Since 1919"

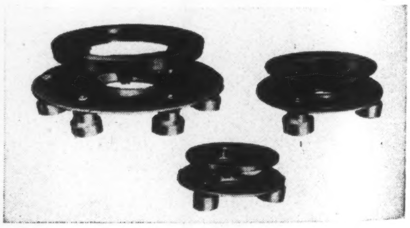


O-ring seals are used. Foot and flange mounts as well as piston rod clevis are available. Made by **A. K. Allen Co.,** 57 Meserole Ave., Brooklyn 22, N. Y.

For more data circle MD-92, Page 227

Centrifugal Switches

For controlling any mechanical or electrical device with rotary motion, Synchro-Snap centrifugal switches are now available in three models, the largest of which is suitable for units rated up to 5 hp. Throw-out speeds of the switches are adjustable and are accurate to ±2½ per cent. Switching is completed at a predetermined speed within three revolutions of the shaft to which it is attached. Snap-action eliminates fluttering or chattering. Action is determined by speed alone, regardless of voltage or load. Made by **Torq Engineered Products Inc.,** Interstate St., Bedford, O.



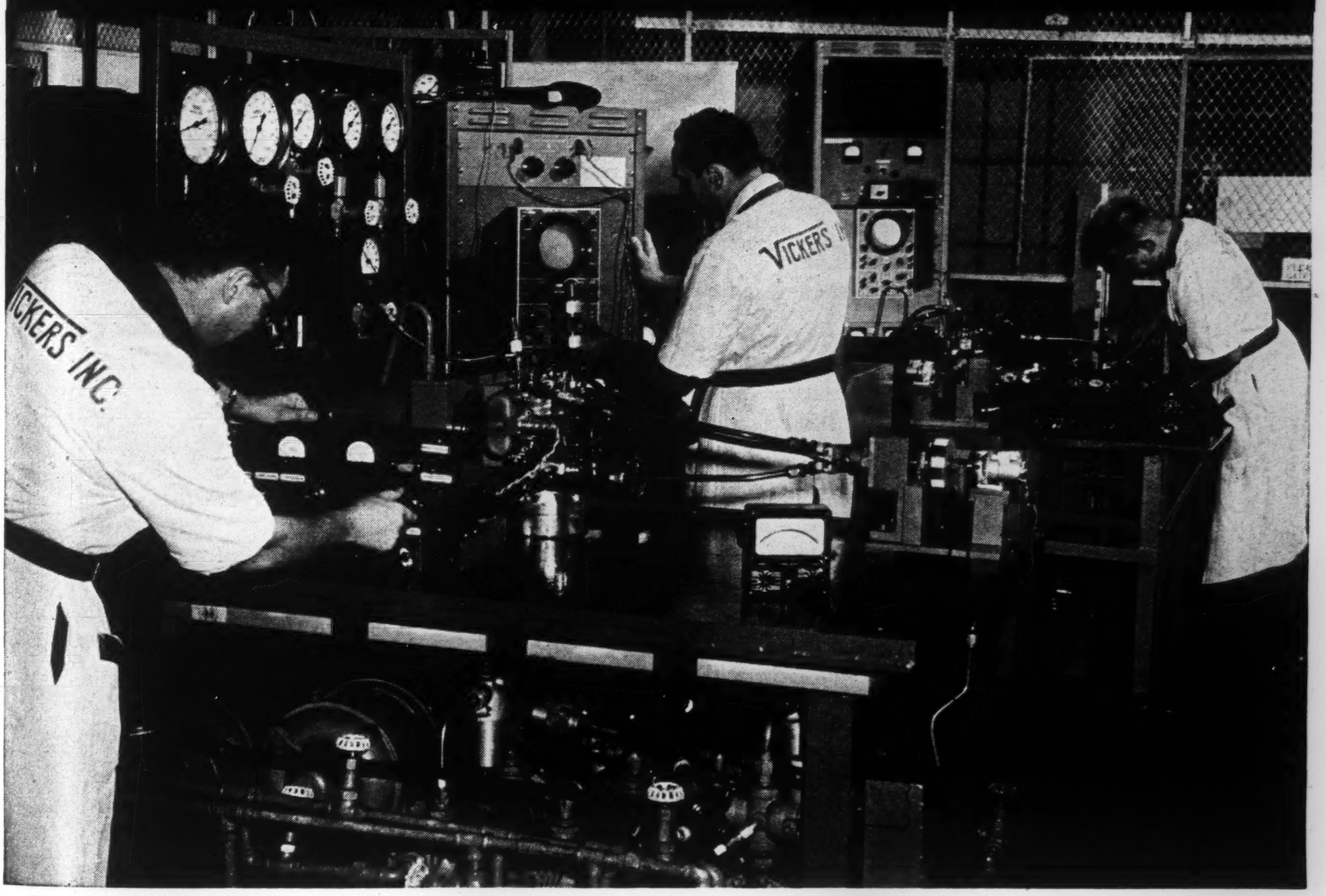
For more data circle MD-93, Page 227

Paper-Base Plastic

Possessing good dielectric strength, low dissipation factor and good moisture resistance, Phenolite Grade Y-2401 is a paper-base electrical grade plastic, bonded with a polyester-modified melamine resin. Arc resistance is

ONE OF A SERIES

You Get Many Benefits by Specifying VICKERS® Hydraulics



Research | that means improved oil hydraulic equipment

The list of pioneering developments in hydraulics contributed by Vickers research is long and impressive. Among the most important are:

Hydrostatic Relief Valve • Commercial Power Steering • Balanced Vane Type Pump • Flow Control Compensator • Axial Piston Pump and Motor

These are fundamental developments that have been of vital importance in the progress of hydraulics. They are representative of a large line of equipment that, with Vickers experienced application, assures you the best in any type of hydraulic operation. Vickers, with unmatched laboratory and basic research facilities, continues to lead the way in the oil hydraulics industry.

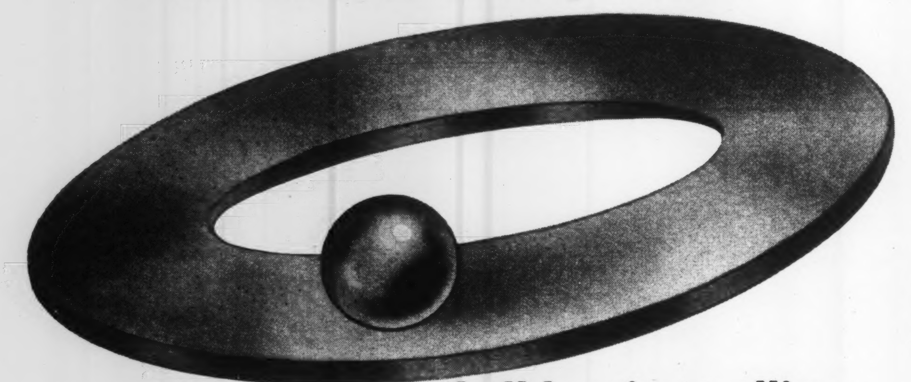
VICKERS Incorporated
DIVISION OF THE SPERRY CORPORATION
1430 OAKMAN BLVD. • DETROIT 32, MICH.

Application Engineering Offices: **ATLANTA • CHICAGO (Metropolitan) • CINCINNATI • CLEVELAND DETROIT • HOUSTON • LOS ANGELES (Metropolitan) • NEW YORK (Metropolitan) • PHILADELPHIA PITTSBURGH • ROCHESTER • ROCKFORD • SEATTLE • TULSA • WASHINGTON • WORCESTER**

6626

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

an old principle —an extraordinary result



ball bearings rolling on a FLAT surface

- *offer less friction*
- *are easy turning*
- *wear longer*

EMSCO BALL BEARING SWIVEL FITTINGS

It's an old principle, a ball rolling on a flat surface — making a single point of contact, and when applied to a ball bearing swivel fitting you get an extraordinary result — free and easy rotation even under extreme pressures. Compare EMSCO on this point!

Should you take the EMSCO fitting apart — and it's easy to do because it breaks like a union, you'll note a unique packing and ball race design which permits easy adjustment for wear. No expensive return of fittings to the factory for service. Note also how the large fluid passageways and smooth, easy contour of bends reduces turbulence and increases flow.

You'll find an EMSCO ball bearing swivel fitting for almost any application.

GET THE COMPLETE ENGINEERING STORY FROM OUR NEW CATALOG TODAY.

8 BASIC STYLES — OVER 500 MODELS

EMSCO
BALL BEARING SWIVEL FITTINGS

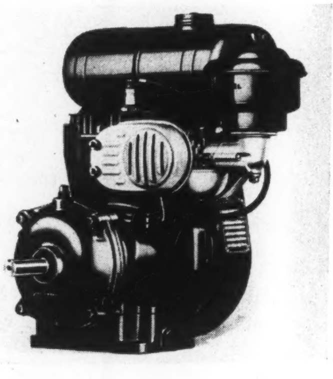
EMSCO MANUFACTURING COMPANY
BOX 2098, TERMINAL ANNEX
Houston, Texas • LOS ANGELES 54, CALIFORNIA • Garland, Texas
Representatives in principal cities

approximately midway between that of paper-base phenolic and paper-base melamine, and machinability is comparable to that of paper-base phenolics. The material can be punched in thicknesses up to ⅛-in., and sections up to ⅜-in. thick can be shaped by shaving dies. It can be drilled, sawed, turned and milled using standard tools and, because it is not brittle, can be rough-blanked close to its final form. Sheets of the ivory colored material are available in sizes up to 39 x 47 in. and 1/32-in. to 1 in. thick. Made by **National Vulcanized Fibre Co.**, Wilmington 99, Del.

For more data circle MD-94, Page 227

Air-Cooled Engine

Model K90R air-cooled engine has a reduction unit which provides a 6 to 1 gear ratio for applications requiring low power take-off speeds. An oil bath air-cleaner, a fly-ball governor and a ball bearing mounted crankshaft are also incorporated in the 3.6-hp, 52-lb engine. Made by **Kohler Co.**, Kohler, Wis.

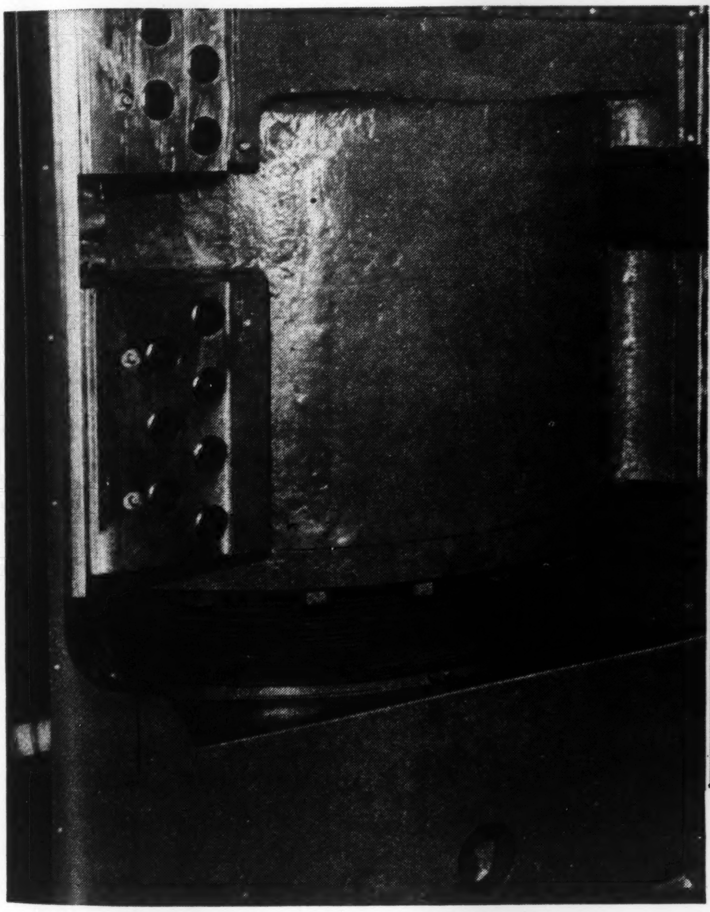


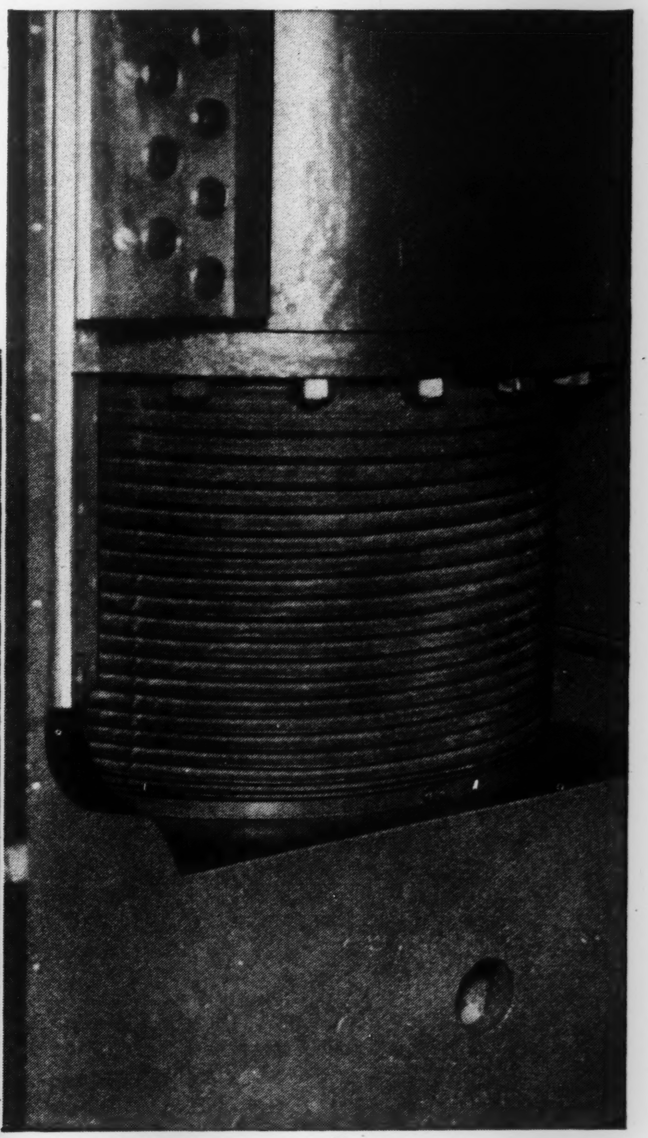
For more data circle MD-95, Page 227

Electronic Relay

Compact model MEK-2403 electronic relay is easy to install and operate. It can operate with a high resistance in its control or initiating circuit; contact resistance of up to almost 1 megohm can be allowed across the initiating contacts. Resistance of control-

New squeeze play with U. S. Multi-Flex Boots





Above is Multi-Flex Boot installed on a hydraulic press ram. Shallower, smaller corrugations mean less installation space necessary.

HERE are some new ideas about design versatility on protective boots. With Multi-Flex® products—a United States Rubber Company development—you can put entirely new advantages into equipment that requires protection for exposed moving parts.

Consider the U. S. Multi-Flex Boot. It completely shields the ram shown above from scoring by grit and other abrasives, yet occupies minimum installation space. Multi-Flex Boots meet travel requirements impossible in conventional boots. They also guard any precision-machine part—such as a piston, worm gear or adjusting screws. Custom made of rubber or rubber and fabric, they are produced without molds by this exclusive "U. S." process.

Multi-Flex Boots also are available in Silicone or Fiberglas constructions to handle temperatures from 65 degrees to 500 degrees . . . and are made to order in inside diameters from 1″ to 36″.

Machine tools, lift trucks, tractors, mining machinery, stamping presses are but a few of the many items that are now equipped with Multi-Flex. For engineering advice and assistance, get in touch with any of our 27 District Sales Offices or write to address below for a free copy of our Multi-Flex Catalog.

"U. S." Research perfects it
"U. S." Production builds it
U. S. Industry depends on it

UNITED STATES RUBBER COMPANY

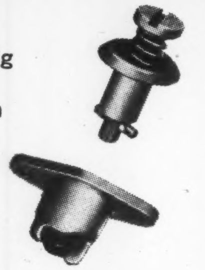
MECHANICAL GOODS DIVISION • ROCKEFELLER CENTER, NEW YORK 20, N. Y.

Hose • Belting • Expansion Joints • Rubber-to-metal Products • Oil Field Specialties • Plastic Pipe and Fittings • Grinding Wheels • Packings • Tapes Molded and Extruded Rubber and Plastic Products • Protective Linings and Coatings • Conductive Rubber • Adhesives • Roll Coverings • Mats and Matting

for a better grasp of any fastener problem— CAMLOC

QUARTER-TURN FASTENERS

MEAN QUICK ACCESS. On panels, doors or covers, Camloc Fasteners provide positive locking by a quarter-turn with a screw driver or wing head. They're vibration-proof, because the action of cam, spring and detent creates a uniform locking torque that grips firmly. Camloc Quarter-Turn Fasteners cost less to install... minimize replacement... fewer do the job.

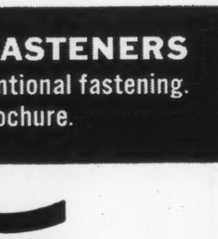


HEAVY DUTY LATCHES

SAFELY AND EASILY OPERATED. Where high shear-tension capacity is a factor...where opening and closing must be done under heavy loads—Camloc has the answer. Spring-loaded handle, retracting sheer pin, positive locking are among the many design advantages.

SPECIAL PURPOSE FASTENERS

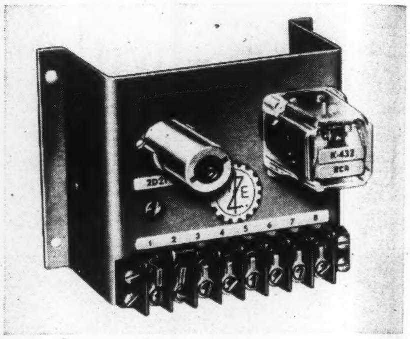
SUITED TO YOUR NEEDS. In the electronics, aircraft, machinery and many other fields, leading original equipment manufacturers are calling on Camloc's Engineering Department to design special fasteners that increase accessibility.



If you have any fastener problem, write for our catalog or specific information.

soon! STRESSED PANEL FASTENERS
A complete departure from conventional fastening.
Write for illustrated brochure.

CAMLOC®
FASTENER CORPORATION
37 Spring Valley Road, Paramus, N. J.
WEST COAST OFFICE: 5410 WILSHIRE BLVD., LOS ANGELES, CAL.

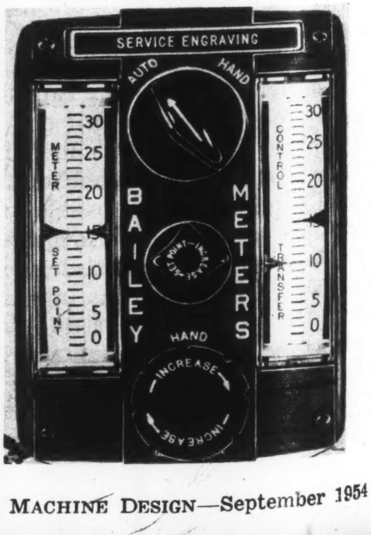


ling contacts can vary over wide limits from one operation to the next. Control circuit voltage and current are very low, permitting use of delicate contacts with minimum separation. Arcing across control contacts is eliminated. Load contacts for control of external circuits provide a means to operate load circuits from delicate mechanisms or contacts, liquids or extremely light pressures that normally cannot perform this function directly. Made by **Machinery Electrification Inc.,** Northboro, Mass.

For more data circle MD-96, Page 227

Control Station

Mini-Line control station for pneumatic control system provides a choice of remote manual control independent of all automatic controllers for starting and stopping and for periods where the measuring and/or controlling elements may be out of service. Quick transfer from automatic to hand control may be made without any disturbance to the process. Ver-



Let this unique illustration convey to you the remarkable cooling effect of Howell's new internal ventilation system in Series 100 Motors.

New Howell re-rated motors run cooler... save space

Here are *completely* new motors . . . built with your design requirements in mind . . . smaller, lighter, cooler running, with generous overload capacity!

Now! Howell brings you everything you want in a re-rated motor: smaller size and lighter weight . . . plus *better cooling* for less maintenance and longer life.

Howell Series 100 re-rated motors feature a new internal ventilation system that provides 50% more contact between cooling air and active lamination materials. Temperature ratings are easily maintained; overload capacity is increased.

Many New Features

Series 100 Motors offer many other advantages: *They take up less space* – up to 30% less in some sizes; both open and totally enclosed fan-cooled motors have same diameters. *They perform better* – Howell uses dependable copper rotors for higher conductivity, greater flexibility; new Mylar* slot insulation is thinner (more space for copper windings), yet eight times stronger. *They last longer* – better cooling, double-shielded bearings and super tough steel frames and feet, with cast iron endplates, insure extra years of trouble-free performance. *They fit your special needs* – Howell provides rotors in three diameters for each frame size; corrosion-resistant materials and fittings are available to meet your specific industry problems.

Before you buy any re-rated motor, compare Howell Series 100 Motors for modern design, outstanding performance, and engineered precision. Howell will continue to make a complete line of regular and special motors – we have in our files more than 20,000 electrical design specifications! Let us serve you. Call your Howell man today.

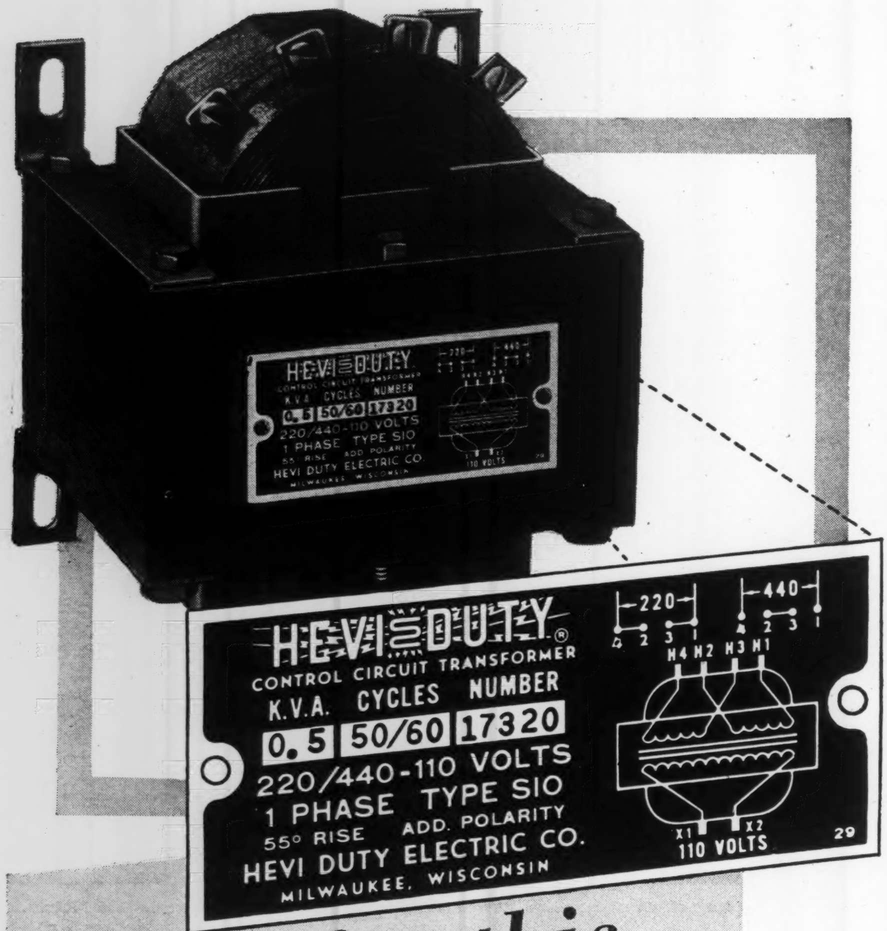
*DuPont trade mark

HOWELL *Red Band* MOTORS

HOWELL MOTORS

Howell Electric Motors Company, Howell, Michigan

MOTORS FOR INDUSTRY SINCE 1915



Look for this Sign of Quality

...on your

CONTROL CIRCUIT TRANSFORMERS!

It Assures HEVI DUTY Quality in a transformer Including These 4 Outstanding Features . . .

★ **LOW REACTANCE.** Interleaved windings give excellent voltage regulation at low power factor, high inrush loads.

★ **COMPACTNESS.** Saving valuable panel space, this Hevi Duty Transformer is able to do a better job than many larger transformers.

★ **HIGH DIELECTRIC STRENGTH.** Coils impregnated with acid and moisture resistant polymerizing varnish.

★ **TESTED** to NEMA and ASA Standards.

Terminal Connecting Type available in sizes from 30 VA to 10,000 VA. Complete information showing regulation curves, impedance characteristics, mounting dimensions, and other engineering data in *Bulletin T-5111.*

HEVI DUTY ELECTRIC COMPANY

MILWAUKEE 1, WISCONSIN

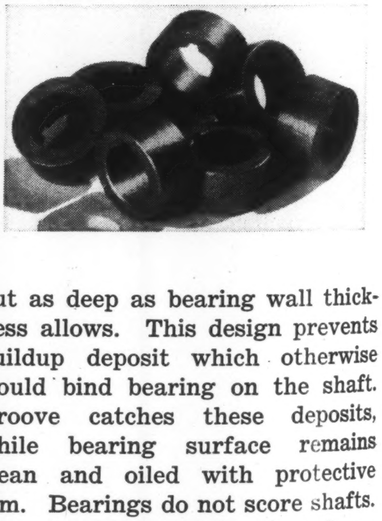
Heat Treating Furnaces . . . Electric Exclusively
Dry Type Transformers Constant Current Regulators

tical gages indicate signals from the transmitter, set point or bias, hand control, and automatic control. The three control knobs are for automatic-hand selection, set point or bias adjustment, and hand control. Unit operates on standard SAMA signal ranges of 3-15 or 3-27 psig. Flush mounting requires a 6¼ x 4½-in. area. Gage accuracy is within ±½ per cent of signal range, and air consumption is less than 0.2 cfm. Made by **Bailey Meter Co.,** 1050 Ivanhoe Rd., Cleveland 10, O.

For more data circle MD-97, Page 227

Sintered Bearings

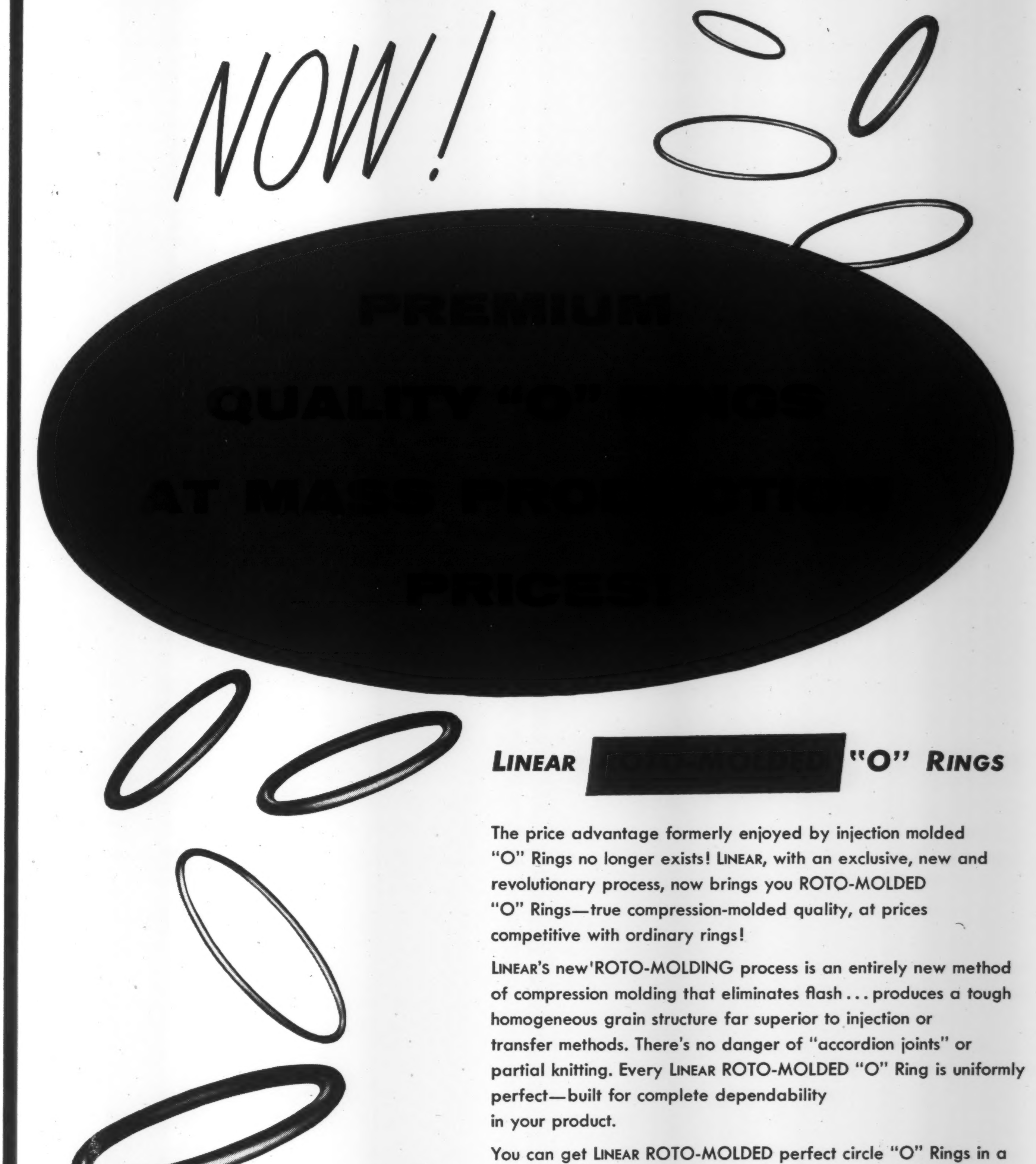
Sintered graphited bearings for fractional horsepower electric motors, appliances, textile and automotive equipment are now offered with groove running length of bearing. Groove is of narrow width, but as deep as bearing wall thickness allows. This design prevents buildup deposit which otherwise would bind bearing on the shaft. Groove catches these deposits, while bearing surface remains clean and oiled with protective film. Bearings do not score shafts. Made by **Wakefield Bearing Corp.,** Wakefield, Mass.



For more data circle MD-98, Page 227

Wing Nut

Now available in size 5/16-in.-18, this wing type finger-tightened fastener is a single thread nut stamped of spring steel, heat treated and tempered after forming. Locking part of the nut is conical and has a center hole with inner edges formed to the pitch of the screw thread. Slots



NOW!

PREMIUM
QUALITY "O" RINGS
AT MASS PRODUCTION
PRICES!

LINEAR ROTO-MOLDED "O" RINGS

The price advantage formerly enjoyed by injection molded "O" Rings no longer exists! LINEAR, with an exclusive, new and revolutionary process, now brings you ROTO-MOLDED "O" Rings—true compression-molded quality, at prices competitive with ordinary rings!

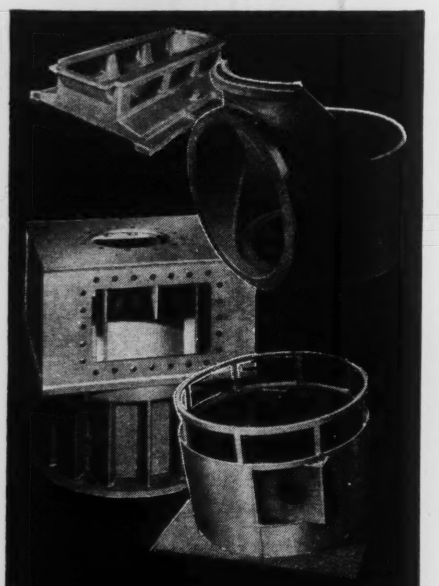
LINEAR'S new ROTO-MOLDING process is an entirely new method of compression molding that eliminates flash . . . produces a tough homogeneous grain structure far superior to injection or transfer methods. There's no danger of "accordion joints" or partial knitting. Every LINEAR ROTO-MOLDED "O" Ring is uniformly perfect—built for complete dependability in your product.

You can get LINEAR ROTO-MOLDED perfect circle "O" Rings in a variety of standard sizes and compounds—or in special sizes and compounds to meet your requirements. Get the facts now!

"PERFECTLY ENGINEERED PACKINGS"
LINEAR
LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA.

with... LITTLEFORD
WELDMENTS,
BASES,
SUB-ASSEMBLIES
you get!

CORRECT DESIGN
ACCURATE FABRICATION
SAVING IN WEIGHT
HIGHER STRENGTH
LOWER COST



Fabricated Weldments, Bases and Sub-Assemblies are demanded by industry today because they insure accuracy, economy and modern design. They provide strength that withstands shock, strain, vibration, reduces machining and weight.

Littleford Fabricated Weldments, Bases and Sub-Assemblies are backed by years of experience in shearing, bending, forming, welding and finishing plate and sheet metals. Littleford has never lost sight of the fact that accuracy and quality are essential to the finished product. If you have a problem involving Fabricated Weldments, Bases or Sub-Assemblies, send blueprints to Littleford and see how experience can give low-cost quality products.

FABRICATORS
OF
PLATE AND
SHEET METAL
PRODUCTS
FOR INDUSTRY
SINCE 1882

LITTLEFORD

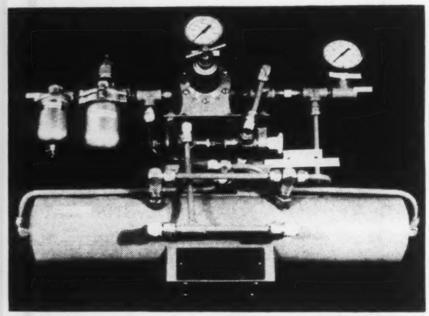
LITTLEFORD BROS., INC.
424 E. Pearl St., Cincinnati 2, Ohio

on the inner edge form spring jaws which close in and grip the screw thread when the nut is tightened. Standard nuts have cadmium finish; brass or nickel plated nuts are available. Other sizes available are No. 6-32, 8-32, 10-32, 10-24 and ¼-in.-20. Made by **Palnut Co.,** 61 Cordier St., Irvington 11, N. J.

For more data circle MD-99, Page 227

Pneumatic Booster Pump

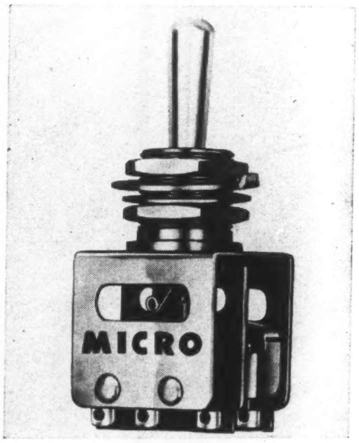
Working on the differential area principle, this automatic pneumatic booster pump can be regulated to supply air at any pressure between one and two times the input pressure. Using a 95 psi input, pump takes 1 minute to boost a 12-gal tank precharged at 100 psi up to 185 psi. Unit includes valves, filter and lubricator, gages and other equipment mounted on a common plate. Made by **Dayton Rogers Mfg. Co.,** 2824 Thirteenth Ave. S., Minneapolis 7, Minn.



For more data circle MD-100, Page 227

Subminiature Switches

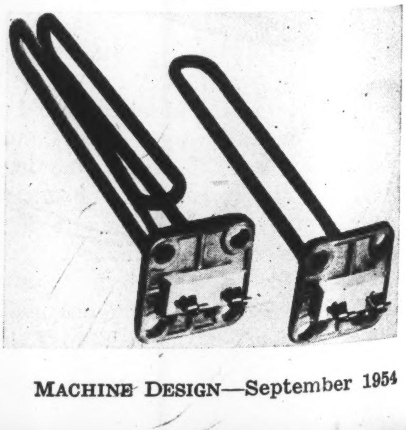
Two single-pole, double-throw basic switching units, providing control of up to four circuits, are contained in this Micro-Switch 13AT three-position, panel-mounting subminiature toggle switch assembly. One unit is actuated in each extreme toggle position, though neither unit is actuated in center toggle position. Thus, it is possible to have three different combinations of two circuits open and two circuits closed at any time. Switches are rated 125, 250 v ac, 5 amp; 30 v dc, 3 amp inductive at sea level, 2.5 amp inductive at 50,000 ft, 4 amp resistive at sea level and 4 amp resistive at 50,000 ft. They have standard bushing and bat handle. Made by Micro Switch Div., **Minneapolis-Honeywell Regulator Co.,** Freeport, Ill.



For more data circle MD-101, Page 227

Immersion Heaters

Single and double-flange Calrod immersion heaters operate on either ac or dc circuits at 115 or 230 v. Wattage ratings range from 750 to 2500 w. A silicone seal and porcelain insulator are incorporated at the heaters' terminal ends as a protection against vapors and

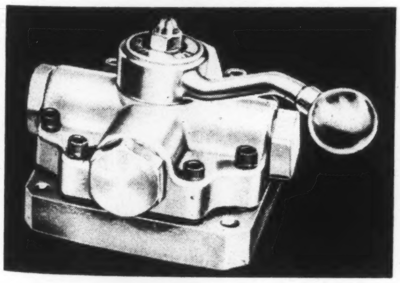


liquids and as an electrical insulator. Terminal connectors are welded to low-resistance cold terminals which are attached to the resistance wire. Heaters are suitable for maximum working pressures up to 125 psi. Made by Industrial Heating Dept., **General Electric Co.,** Schenectady 5, N. Y.

For more data circle MD-102, Page 227

Poppet Valve

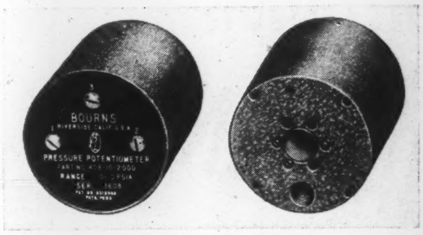
Measuring 2 in. high, compact, four-way "Pancake" valve is actuated by means of a rotary handle. It has bottom-ported base and is available in ¼ and ⅜-in. pipe sizes. Valve seals with air pressure; pressure rating is 125 psig. Maximum recommended operating temperature is 175 F. Valve may be adapted for use at higher or lower pressures and for services other than air. Made by **Ross Operating Valve Co.,** Dept. 3101, 120 E. Golden Gate, Detroit 3, Mich.



For more data circle MD-103, Page 227

Potentiometer

Capable of withstanding 50 *g* longitudinal acceleration with less than 1 per cent error, model 408 absolute pressure potentiometer measures altitude, fuel pressure, throat and static pressure in a variety of applications. Static reference pressure is provided by an evacuated aneroid type bellows. Lightweight and compact instrument is rated at ½-w output, sufficient for direct connection to recorders and control systems. Many standard pressure ranges are available, including 0-2, 0-8, 0-30, 5-10, 13-14.7 psia. Standard resistance values are 1000, 2000, 5000 and 10,000 ohms. Made by **Bourns Laboratories,** 6135 Magnolia Ave., Riverside, Calif.



For more data circle MD-104, Page 227

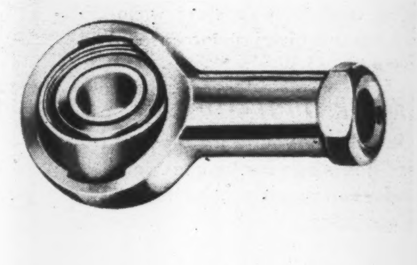
Plastic Hose

Flexible R-500 plastic hose, made from fluorocarbon resins, handles corrosive liquids and is resistant to temperature extremes. Light in weight, the hose is available in diameters ranging from ¼-in. to 1 in. Made by **Resistoflex Corp.,** 39 Plansoen St., Belleville 9, N. J.

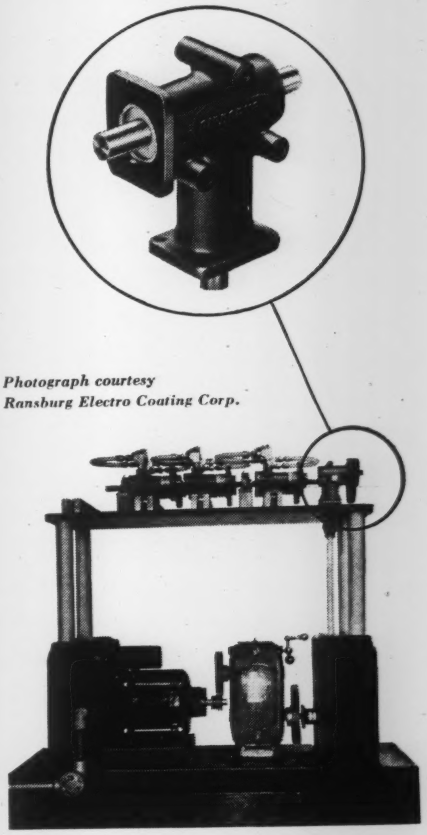
For more data circle MD-105, Page 227

Connecting Rod Ends

Connecting rod ends are made with spherical bearings. Ball bearings are free of friction and rotate in the housing to correct misalignment up to 20 degrees. Bearings are easily removed and replaced for overhaul and are protected from abrasion by double dust shields. Housing stem is internally threaded either right or left hand. Three bolt hole sizes of 3/16, ¼ and ⅜-in. are available, rod lengths being 1⅛, 1 7/16 and 2 1/16-in., respectively. Complete sets consisting of ball bearing ends, lock springs and rods of



Why they select
ANGLGear
TRADE-MARK



Photograph courtesy
Ransburg Electro Coating Corp.

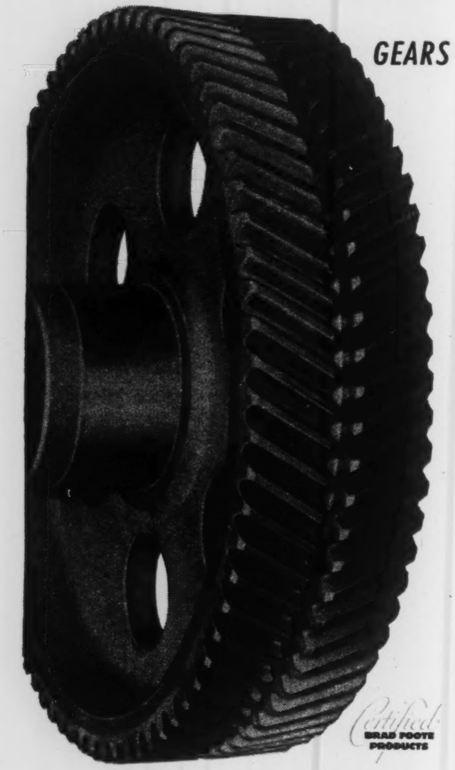
ANGLgear is the power takeoff between the motor and nozzles of this new electrostatic paint spray unit.

WHENEVER designers discover a new application for this right-angle bevel gear, you usually find—as in the case above—that their selection was based on three product advantages: small size, high capacity, and low cost. List price on the small ⅛ h.p. model, $19.50; and on the 1 h.p. model, $39.75. Contact your distributor or write us for information.

AIRBORNE
Accessories Corporation
HILLSIDE 5, NEW JERSEY

Distortion is Controlled in **BRAD FOOTE'S** DEEP CASE HARDENING

The BRAD FOOTE **DEEP** CASE HARDENING process has been perfected to a degree which practically eliminates distortion



GEARS RUN TRUE

No place is distortion control more important than on heavy duty gears which are run almost continuously at full rating and subjected to extreme shock loads such as are encountered in rolling mill operations. BRAD FOOTE **DEEP CASE HARDENED** gears run true and distribute the load evenly across the full face and on the designed bearing surfaces of each tooth.

HARD TOOTH SURFACES

In addition, BRAD FOOTE rigidly controls to set standards the depth of **DEEP CASE HARDENING** and the carbon content. The tooth surfaces are of maximum hardness for long life, but the carbon content is gradually diminished at successive depths below the surface until it blends to the metal of the core itself.

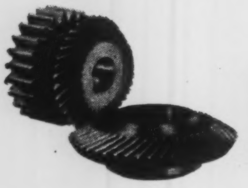
SHOCK-RESISTANT CORES

Thus the cores of the teeth and the body of the gear remain ductile and shock-resistant while the teeth are given an increase in service life of over 50%.

ASK FOR QUOTATION

It will pay you to try a set of these gears on your toughest job. Send your specifications today for quotation.

BRAD FOOTE makes Spur
Bevel
Helical
Spiral Bevel
Herringbone
Zerol
Worms
Worm Gears
Reducers
Transmissions



BRAD FOOTE GEAR WORKS, INC.

1309 South Cicero Avenue • Cicero 50, Illinois
Bishop 2-1070 • OLympic 2-7700 • TWX: CIC-2856-U

subsidiaries

AMERICAN GEAR & MFG. CO.
Phone: Lemont 920
Lemont, Illinois

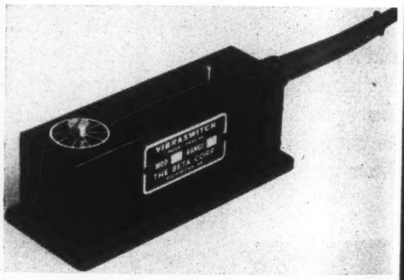
PITTSBURGH GEAR COMPANY
Phone: SPaulding 1-4600
Pittsburgh 25, Pennsylvania

any desired length are also available. Made by **Avalon Machine Products Inc.**, 2535 E. Imperial Highway, Los Angeles 59, Calif.

For more data circle MD-106, Page 227

Vibration Meter

Model 1 Vibraswitch serves as a protective monitoring switch to actuate a warning or shut down a machine when vibration exceeds the normal value by a preadjusted amount. Flat response from 0 to 200 cycles per second assures reliable operation on almost all types of rotating or vibrating equipment.



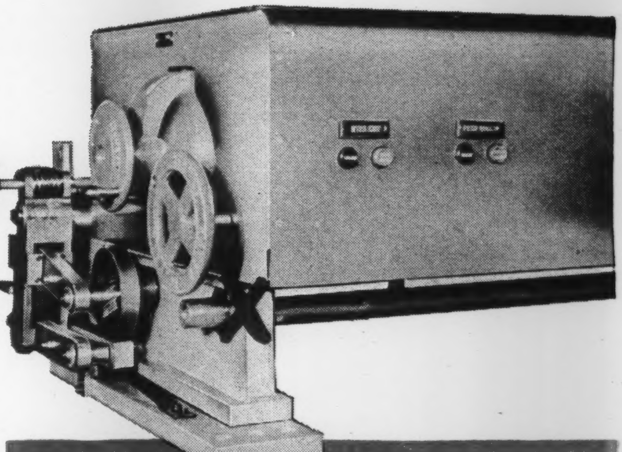
An internal single-pole, double-throw manually resettable switch may be used to control circuits at up to 5 amp with vibratory displacement increases of as low as 10 mu in. at 12,000 rpm. Acceleration range is 0 to 2 *g* or 0 to 800 ips^2 with an accuracy of ±0.05 *g*. Device measures 5¼ x 2¼ x 2½ in.; weighs 19 oz. Model 2 is less sensitive and has a range of 0 to 20 *g*. Made by **Beta Corp.**, P. O. Box 8625, Richmond 26, Va.

For more data circle MD-107, Page 227

Push-On Connectors

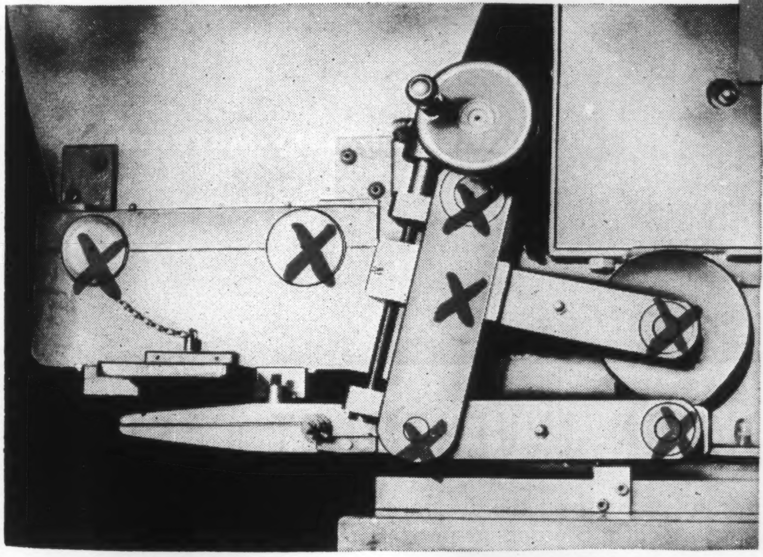
Faston push-on connectors are now available in flag design for fast right-angle connection. Connectors have triple spring action and wide wiping contact. They push onto mating tab receptacle to make connection. The connector will accommodate all insulations normally used in automotive and appliance wiring in sizes No. 18 through 12 AWG. Connectors are furnished in strip form wound on reels for use on A-MP automatic

"X" marks the spots



where Weidenmiller Cookie Cutters "gained close precision and eliminated roller skewing" by installing

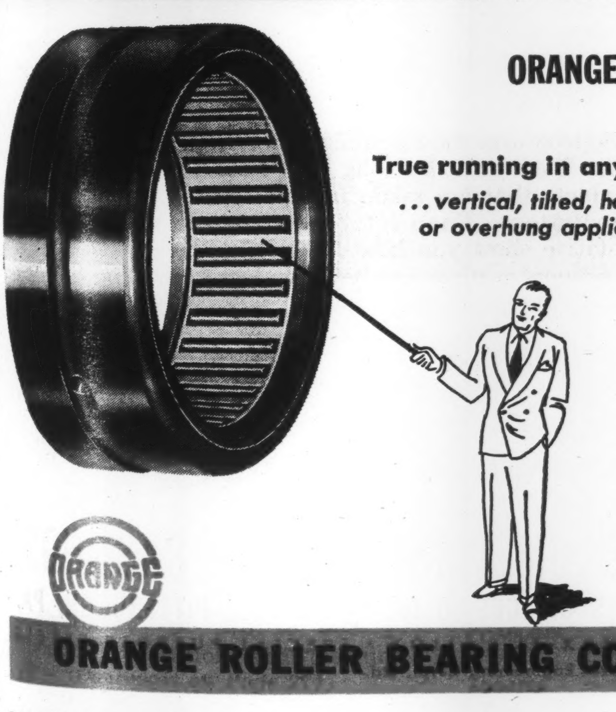
ORANGE *Cage Type* NEEDLE BEARINGS



"Very fine service — trouble-free!"

—reports Edw. Weidenmiller Co., Inc., Morton Grove, Ill., after about 2 years' experience with Orange Cage Type Needle Bearings in their wire cut machines used for cutting cookies on 32″ and 38″ continuous baking ovens. In all, 20 bearings are used in the feed rolls, drive shafts and all mechanical wire cut mechanism parts. Closeup view at left shows unusual combination of operating conditions met by bearings, due to design requirements.

ORANGE Cage Design assures alignment of rollers—prevents skewing



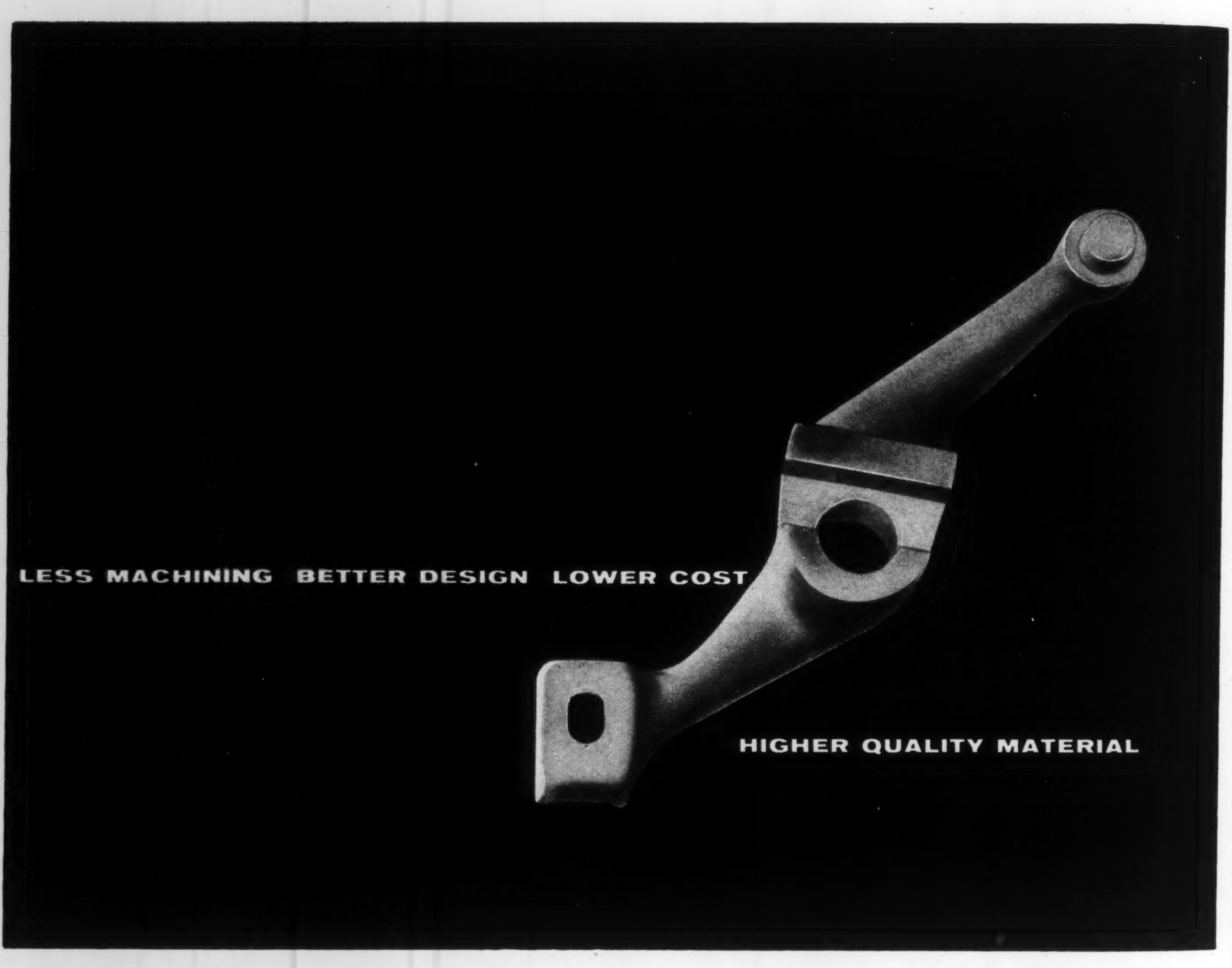
True running in any position
. . . vertical, tilted, horizontal or overhung applications

Note that square-end rollers are held in alignment by pockets of a free-floating, land-riding cage made of anti-friction, nonferrous metal. This cage merely guides—does not wear on rollers.

This feature has placed Orange Cage Type Needle Bearings in many applications hitherto unsuited to conventional types—providing high load capacity in small space, with exceptionally smooth, quiet, trouble-free operation under practically every type of running condition. Stock sizes from ½″ to 8″ shaft dia., fully interchangeable with standard heavy-duty needle bearings. Write for Engineering Data Folder.

ORANGE

ORANGE ROLLER BEARING CO., Inc. 556 Main St., Orange, N. J.



thanks to **ACCUMET PRECISION INVESTMENT CASTINGS**

This bolt-making machine transfer arm used to be machined from a forging of SAE 1045 steel. A grooved pin had to be machined and assembled in the forging, and many milling, broaching and drilling operations were needed to produce the finished part.

Then a Crucible ACCUMET® precision investment casting was tried, using heat-treated SAE 4140. Results? All machining except drilling and tapping two small holes was eliminated. Better functional design was achieved. A more rugged grade of steel was used. The manufacturer's machine tools were released for other jobs.

This is just one example of hundreds where ACCUMET precision investment castings have improved the design, function and performance of a component part — *with a reduction in cost.* It was possible because Crucible — the country's leading specialty steel producer — has established standards of quality and uniformity in its ACCUMET precision castings that are unsurpassed in the industry.

So look over the machining operations in your shop. Take an *extra* long look at the intricate products that are made in many costly, high-reject steps. Then let your Crucible representative show you how ACCUMET precision investment castings can help you lower costs and improve your products.

Buy U.S. Savings Bonds

CRUCIBLE first name in special purpose steels

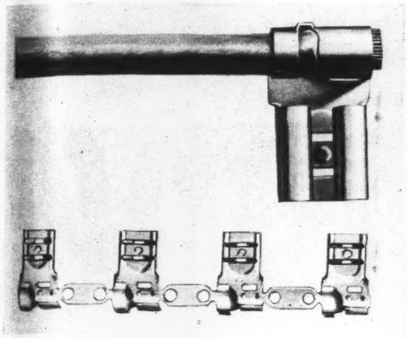
54 *years of* *Fine* *steelmaking*

ACCUMET INVESTMENT CASTINGS

CRUCIBLE STEEL COMPANY OF AMERICA, GENERAL SALES OFFICES, OLIVER BUILDING, PITTSBURGH, PA.

REX HIGH SPEED • TOOL • REZISTAL STAINLESS • MAX-EL • ALLOY • SPECIAL PURPOSE STEELS

Canadian Distributor — Railway & Power Engineering Corp., Ltd.

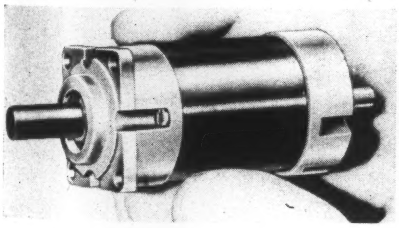


machines. Terminal can be crimped on center strip. Made by **Aircraft-Marine Products Inc.,** 2100 Paxton St., Harrisburg, Pa.

For more data circle MD-108, Page 227

Integral Gear Reducers

Miniature precision integral planetary gear reducers convert high speed into high torque. Continuous long term output torque ranges up to 1000 oz-in., which, for short periods of time, may be greatly exceeded. Basic unit diameter is $1\frac{1}{4}$ in. with a $\frac{3}{16}$-in. diameter input shaft and a $\frac{5}{16}$-in. diameter output shaft. Lengths vary with standard speed reduction ratios of 18.78:1 to 21,808:1. Made by **Globe Industries Inc.,** 1784 Stanley Ave., Dayton 4, O.

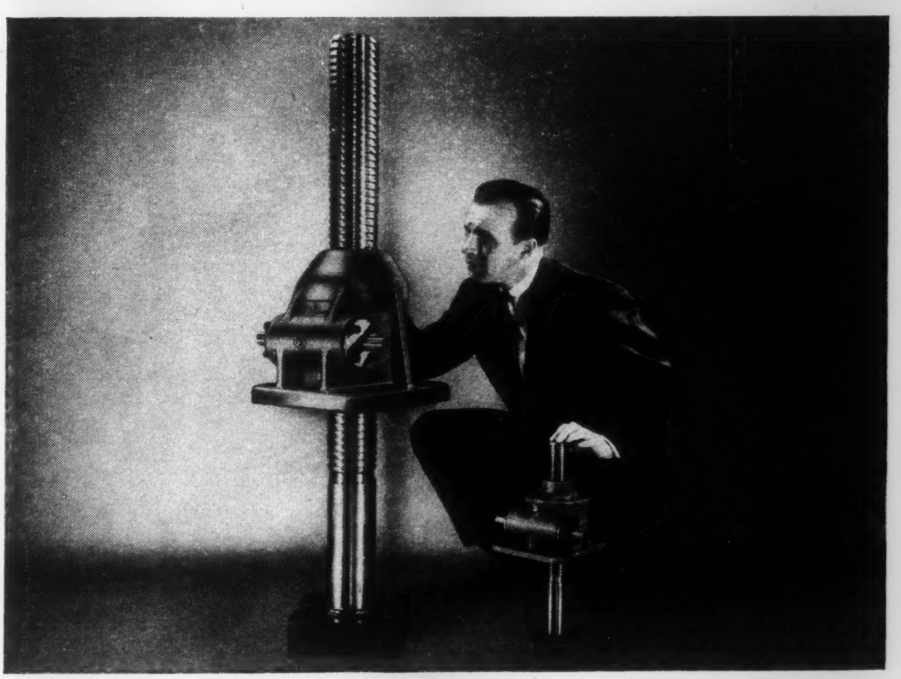


For more data circle MD-109, Page 227

Bonding Metals

Percoloy line of aluminum bonding metals includes three materials for high, medium and low-temperature bonding of aluminum alloys. Solbond, applied with a soldering iron and without flux, is used at temperatures of 375 to 500 F. Special preparation and cleaning

(*Continued on Page 274*)

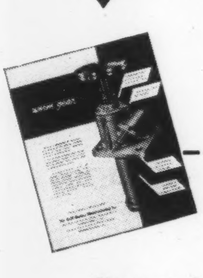


Here's A Device Every Machinery Designer Should Know About . . .

It's the Duff-Norton Worm Gear Jack, successfully used by many machine builders as a component of equipment for precise, positive control of linear motion, applying pressure, resisting impact. Two or more of these jacks can be connected by means of shafting and mitre gear boxes or any power-operated positive control system so that jacks always raise or lower under equal or unequal loads in perfect unison. Capacities range from 5 to 35 tons with any raise up to 25 inches; worm gear ratios, 8:1 to 96:1; turn of worm for each 1-inch raise, 10 to 180; available in either Acme or square threads. Screw ends and tops are available in many types and can be readily adapted to your specific requirements.

Thousands of these jacks are in use today for table adjusting—machine adjusting—rolling mill adjusting—raising and lowering conveyors, machine beds, molds and dies, furnace lids, loading platforms, loading racks, gates, hinged mechanisms, arbor presses—adjusting electrodes—overhead crane servicing.

Duff-Norton Worm Gear Jacks are available in 6 standard sizes or to your special order. For complete specifications and detailed drawings, send for your free copy of a special brochure.



DUFF-NORTON
Manufacturing Company

THE DUFF-NORTON MANUFACTURING CO.
DEPARTMENT MD
P.O. Box 1889, Pittsburgh 30, Pa.

Please send immediately a free copy of your new Worm Gear Jack Brochure.

NAME ____ *TITLE* ____
COMPANY ____ *PHONE* ____
ADDRESS ____

Plenty of Copper

today and tomorrow

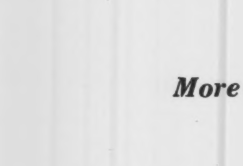
The assurance that copper is in abundant supply and *can be used without restrictions* is the "go ahead" for industry. You can now rate PERFORMANCE over AVAILABILITY when choosing materials. By using copper and its alloys, brass and bronze, your product is easier to fabricate, better and more durable.

We can get more copper than we now have. Although industry and government have been consuming more copper than in any previous peacetime period, production has kept pace with this increased demand. And producers are not working at full capacity!

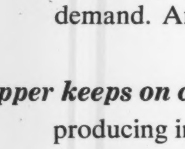
More copper keeps on coming. Eleven major new projects in the U. S. will start producing in the next 3 years. These mines will add 250,000 tons to our annual production—more than *¼ of all the domestic copper mined during 1953*. In addition, recent improvements in mining techniques now make it possible to obtain copper from ores considered commercially unworkable in the past.

Copper is virtually indestructible. At least 3 out of every 4 pounds of copper used in today's products, when scrapped, can be re-used in the future. Every day we are adding to our "copper capital". The more copper we use . . . the more we have!

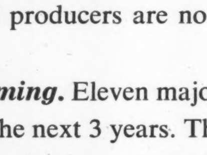
Copper or its alloys provide these advantages . . .



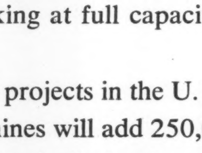
Best conductor of electricity commercially available.



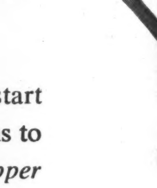
Does not rust . . . high corrosion resistance.



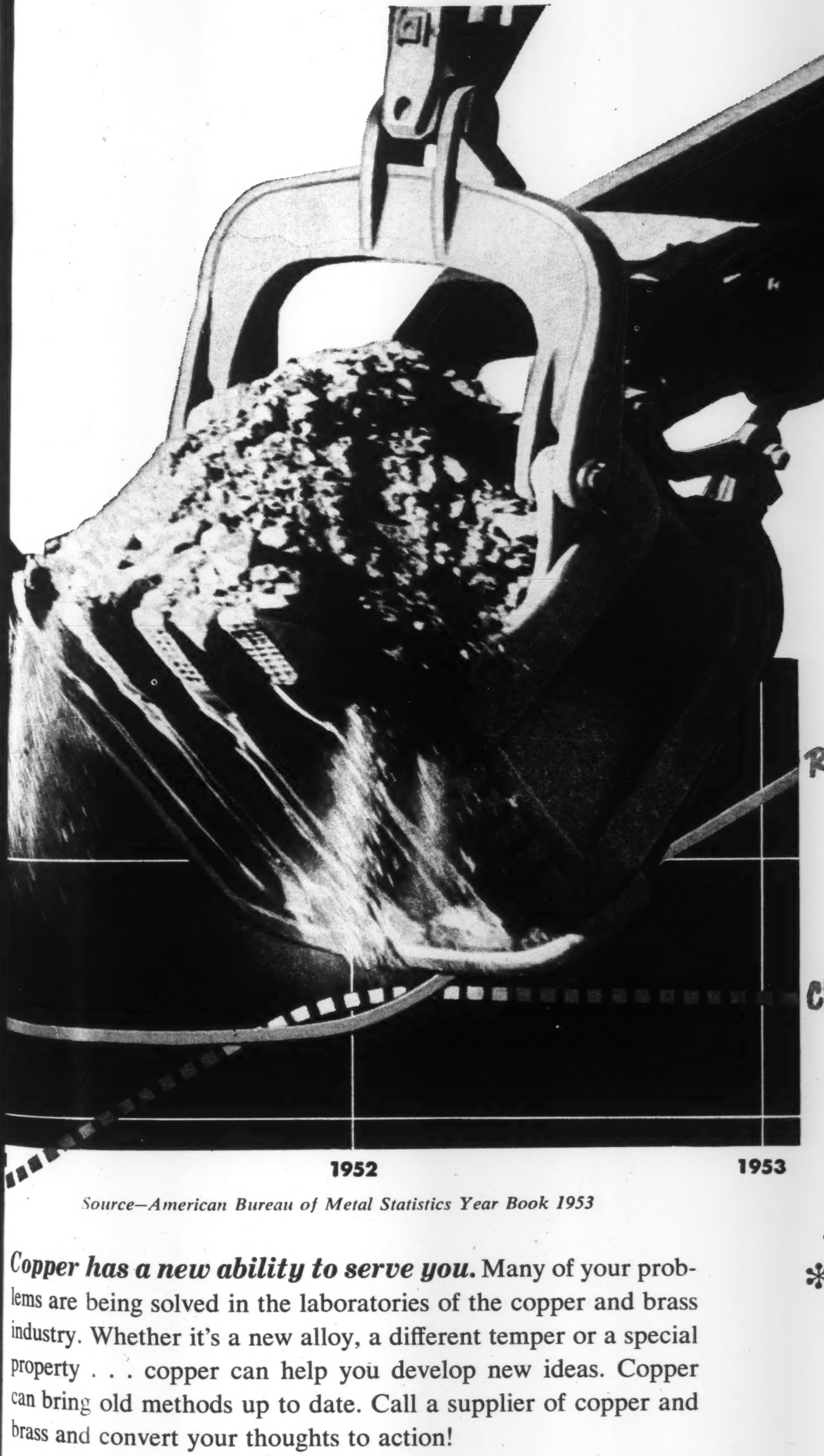
Best heat transfer agent of all commercial metals.



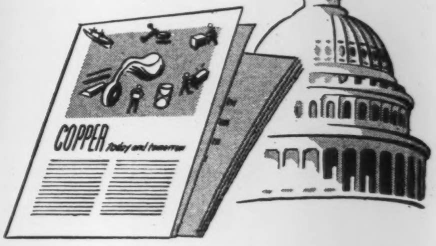
Easy to machine, form, draw, stamp, polish, plate, etc.



Welds readily . . . excellent for soldering and brazing.



Source—American Bureau of Metal Statistics Year Book 1953



Copper has a new ability to serve you. Many of your problems are being solved in the laboratories of the copper and brass industry. Whether it's a new alloy, a different temper or a special property . . . copper can help you develop new ideas. Copper can bring old methods up to date. Call a supplier of copper and brass and convert your thoughts to action!

COPPER & BRASS
Research Association

* ***"Copper . . . is fortunately available in ample supply to meet any foreseeable demand"***

Foreword, U. S. Dept. of Commerce
B.D.S.A. Copper Quarterly, August 1954

For information about U. S. copper supplies including free copies of this Government report and the new booklet, "Copper . . . Today and Tomorrow", send attached coupon to:

Copper & Brass Research Assn., Dpt. J
420 Lexington Ave., New York 17, N. Y.

NAME ....

COMPANY ....

ADDRESS..

CITY ....STATE ....

you can banish fear of component failure

Specify AEMCO RELAYS

. . . BE ASSURED OF DEPENDABLE QUALITY!

The components you purchase lose their identity once they are incorporated in a manufactured unit. To the ultimate consumer, they become *your* product. The failure of the smallest component can, and often does, determine the acceptance for and the success of your unit! That's why AEMCO Relays are built to exceed 'specs' . . . *military or industrial.*

AEMCO Relays are available in a wide variety of spring and coil combinations, operating potentials and contact ratings . . . open, can type, plug-in base, hermetically sealed units . . . midgets, dual purpose, delayed make or break, circuit control, current and potential relays.

Chances are that we are supplying relays to one of your competitors . . . one of the hundreds of AEMCO stock models or one built to meet special needs and mounting requirements. We would like to help underwrite the success of your equipment by furnishing dependable AEMCO Relays *to exceed your most exacting requirements!*

The Services of our Engineering Department are Available on Request. WRITE TODAY!

AEMCO

Automatic Electric MFG. CO.

64 STATE STREET · MANKATO, MINN.

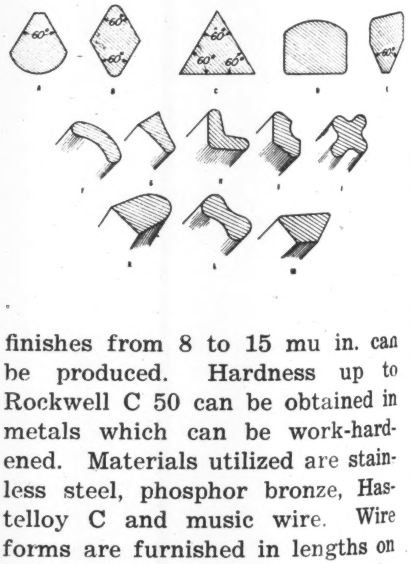
(*Continued from Page* 271)

of the parent metal surface is not required. Brabond can be used on all S or S-T aluminum and produces bonds, by the brazing method, at temperatures of 500 to 800 F. Welbond, applied by welding at temperatures of 800 to 1050 F, can be used at the solution heat-treat temperature of the parent metal, permitting simultaneous bonding and heat treating. Presently made in bar shape, the three materials will be available in a variety of shapes and forms. Made by **Precision Electronic Research Co.**, Glendora, Calif.

For more data circle MD-110, Page 227

Formed Wire

Wire in intricate shapes such as those illustrated is available in sizes ranging from 0.015 to 3/16-in. cross-section. Tolerances can be held to 0.0002-in., and surface finishes from 8 to 15 mu in. can be produced. Hardness up to Rockwell C 50 can be obtained in metals which can be work-hardened. Materials utilized are stainless steel, phosphor bronze, Hastelloy C and music wire. Wire forms are furnished in lengths on spools, reels or in individual coils. Made by **Heli-Coil Corp.**, Shelter Rock Rd., Danbury, Conn.



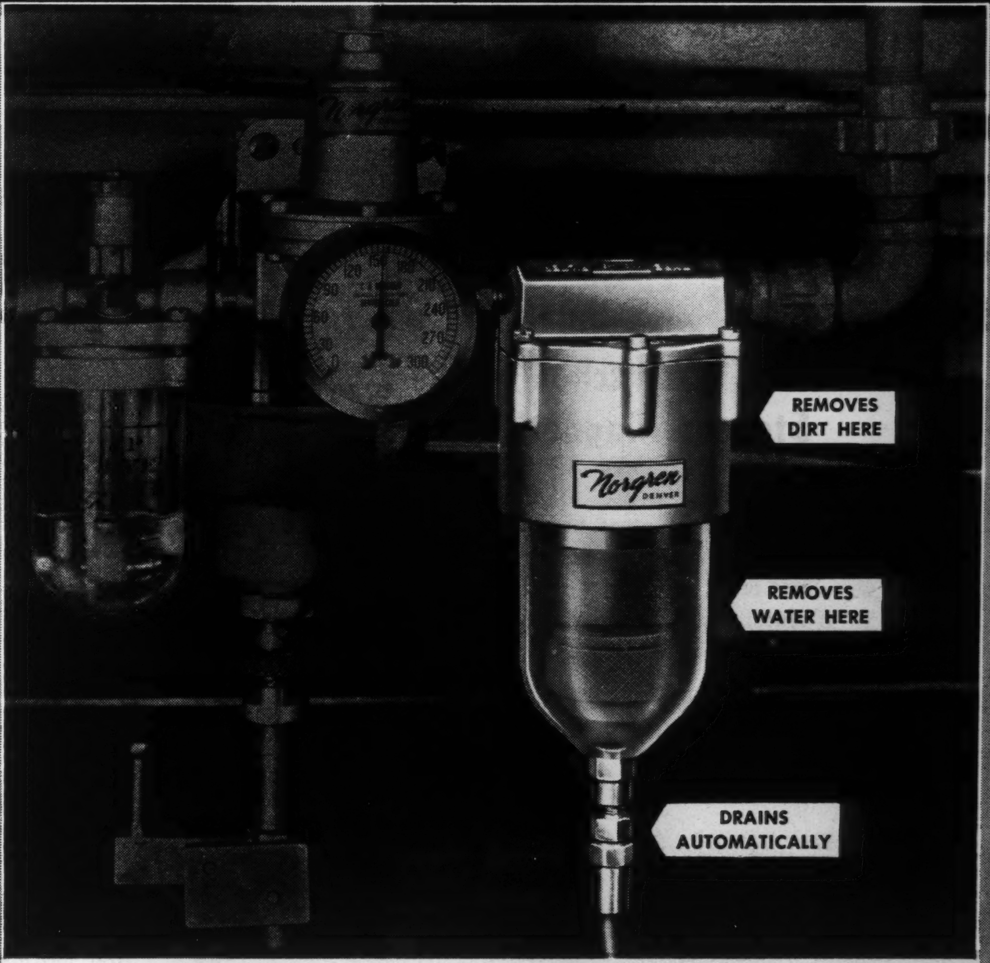
For more data circle MD-111, Page 227

High-Voltage Connector

High-voltage capacity of six-contact connector is made possible by deep wells which surround the individual contacts and prevent arcing. The make-first, break-last center contact permits use as a

24-hour protection for air equipment

with NORGREN AUTOMATIC-DRAIN FILTER



The new Norgren Automatic-Drain Filter operates automatically, whether air pressure is constant or fluctuating, whether or not air is flowing...assuring clean, dry air, without attention.

Performance data prove its efficiency—***100% water removal*** up to flow of 20 cfm, 90% at flow of 30 cfm...at 80 psi primary pressure and flow of 35 cfm ***pressure drop across filter is only 1 psi.***

WRITE FOR NEW CATALOG NO. 600

- New transparent replaceable bowl filter for ¾" and 1" air lines. Water capacity 1 pint.
- Replaceable metal bowl filter for ¼", ⅜" and ½" air lines.
- Permanent metal bowl filter types for ¼" to 1½" air lines.
- New, small replaceable bowl filter for ¼" and ⅜" air lines. Screw type clamp ring.

C. A. Norgren CO.
3442 So. Elati, Englewood, Colo.

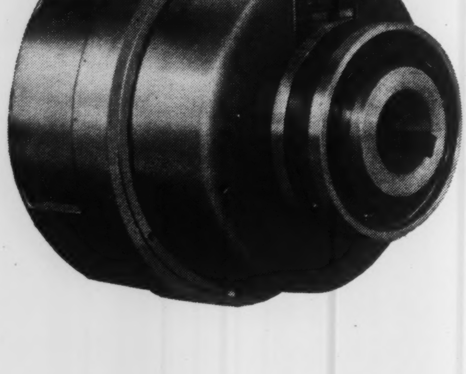
PIONEER AND LEADER IN OIL FOG LUBRICATION FOR 26 YEARS

VALVES • FILTERS • REGULATORS • LUBRICATORS • HOSE ASSEMBLIES

Make tomorrow's push-button ideas work today with a "matched to the machine" Stearns Magnetic Clutch

When you design new installations, modernize or adapt existing machines, be sure of *matched* power transmission control with a Stearns magnetic clutch. Stearns not only builds a wide variety of standard clutches and clutch-brake combinations, but also designs *special custom-built units tailored exactly to your specific installation.*

Make these Stearns advantages work for you:



WIDE TORQUE RANGE — .4 to 30,000 lb foot. Handles everything from business machines to steel mill screwdowns and ball and rod mill drives.

LOW INERTIA — Fast, smooth engagement and disengagement.

VARIED DESIGNS — Through shaft, split shaft, duplex for two speed drives, forward and reverse drives — other special applications.

WIDELY ADAPTABLE — DC or AC with rectifier. Automatic and remote control. Operates in conjunction with electronic circuits.

QUIET AND COOL RUNNING—Generous friction surface area and low unit pressure.

EASY WEAR ADJUSTMENT — Provides longer clutch life.

SIMPLE INSTALLATION — no toggles, yokes, shifters.

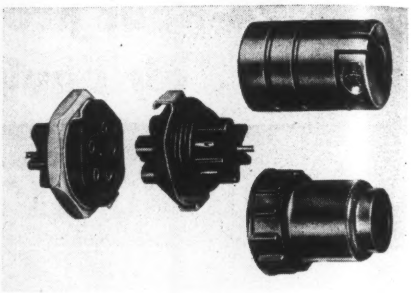
For full details consult your 1954 Sweet's Product Design file or write for Bulletin 226-C-3.

1088

MAGNETIC EQUIPMENT FOR ALL INDUSTRY

STEARNS MAGNETS

STEARNS MAGNETIC, INC., 692 S. 28th St., Milwaukee 46, Wis.

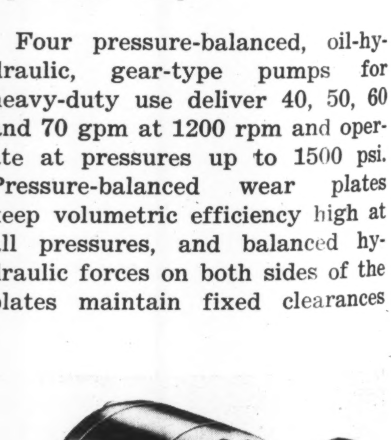


ground. Center key and one-way contact arrangement provide positive polarization. Breakdown at sea level is 4000 v rms, and current rating is 5 amp. Unit has 8-oz maximum disengagement force per contact without sacrific of millivolt drop. Two vibration rings with matching detent action prevent accidental disconnection. Hoods are available in either aluminum, with cable clamp, or molded insulating material. Insulating materials available for body of connector are mineral-filled melamine, plaskon - reinforced alkyd and orlon-filled diallyl phthalate. Available from **DeJur-Amsco Corp.**, 45-01 Northern Blvd., Long Island City 1, N. Y.

For more data circle MD-112, Page 227

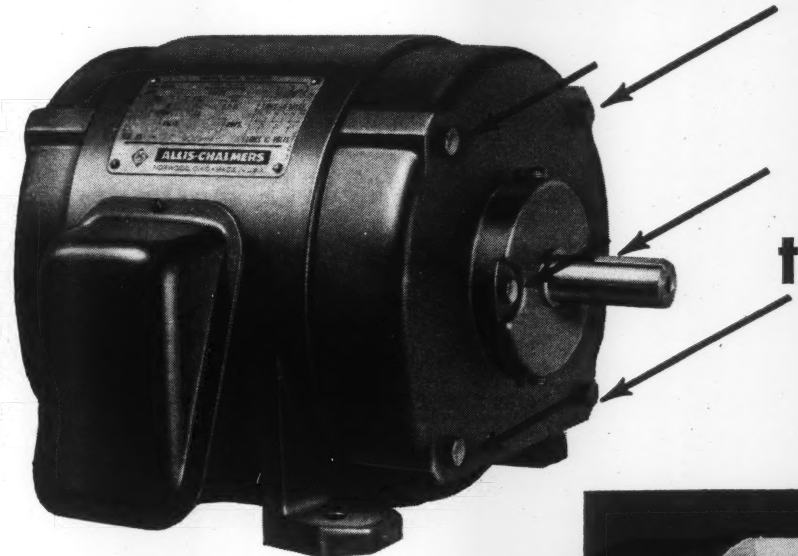
Hydraulic Pumps

Four pressure-balanced, oil-hydraulic, gear-type pumps for heavy-duty use deliver 40, 50, 60 and 70 gpm at 1200 rpm and operate at pressures up to 1500 psi. Pressure-balanced wear plates keep volumetric efficiency high at all pressures, and balanced hydraulic forces on both sides of the plates maintain fixed clearances

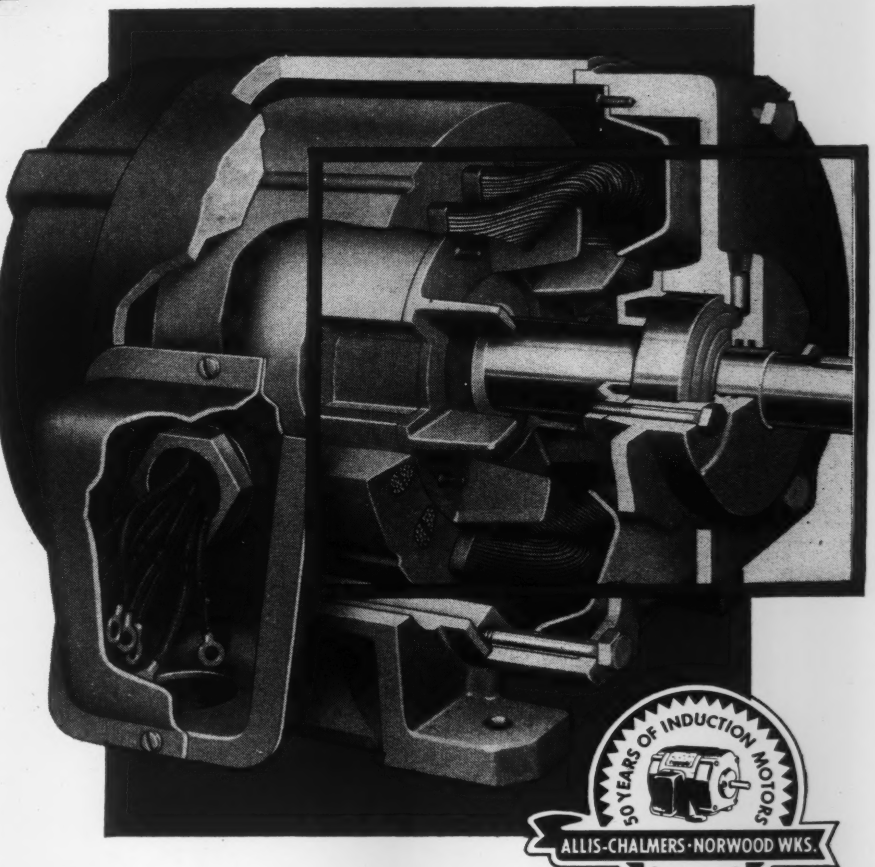


Here's motor superiority

you can see



It takes 6 bolts not just 4 to give full bearing protection



THE TWO EXTRA BOLTS in the end housing of every Allis-Chalmers ball bearing motor are the proof of *extra* protection against bearing failure. These are the bolts that hold the bearing cap tightly in place against the inner face of the bearing enclosure. This cap, with its close running clearances, keeps grease from the interior of the motor . . . retains an ample supply within the bearing enclosure . . . protects the grease and the bearing against contamination from dirt and moisture.

At the outer side of the bearing, double labyrinth seals keep grease in, also keep dirt out. What's more, large grease reservoirs act as additional dirt traps.

Result? Allis-Chalmers motors pay off in longer, trouble-free bearing life, lower motor maintenance.

50 YEARS OF INDUCTION MOTORS

ALLIS-CHALMERS·NORWOOD WKS.

Get all the facts . . . judge for yourself — Compare Allis-Chalmers motors with other motors. Get the six-bolt construction that gives you complete bearing protection. For proof, see your Allis-Chalmers Office or Authorized Distributor, or write — Allis-Chalmers, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

A-4440

~~SURFACE DECARBURIZATION PROBLEMS~~ . . . ELIMINATED

in

INVESTMENT CASTINGS by **ARWOOD'S** new Homocarb Furnace

Design Engineers

Arwood can investment cast intricate or simple shapes at great savings with the assurance of uniform quality — we can guarantee castings with .001" maximum decarburization.

Here's How

Arwood has pioneered again — recognizing the need for investment castings free of surface decarburization, Arwood is the first foundry to install carbon restoration equipment.

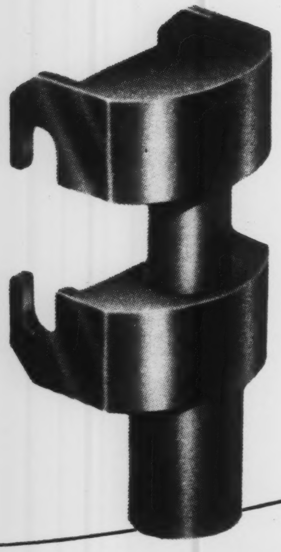
NOW . . .

Carbon and low alloy steel investment castings (1020, 3120, 4130, 4140 and 6150) can now meet all of the most exact metallurgical specifications — including freedom from surface decarburization.

Let **ARWOOD** *help YOU*

solve your production problem — improve your design — save you money — assure you top quality. Drop us a line to have one of our field engineers call on you and discuss how you can best utilize Arwood investment castings.

ASK FOR OUR BOOKLET
"ALLOY SELECTION AND DESIGN FOR PRECISION CASTING"



For the RECORD

These two mating units, pilot and anchor for aircraft clamp ring fastening screw, were previously milled from bar stock.

Using the carbon restoration unit, Arwood was able to meet the strict metallurgical specifications necessary to assure dependable performance.

ALLOY: 4140 (.001" Max. Decarb.)
HEAT TREAT: Double normalize, carbon restore, quench, temper
HARDNESS: Rc 25 Max
COST: 22.5% of machined cost

ARWOOD
PRECISION CASTING Corp.
78 WASHINGTON STREET B'KLYN 1, N. Y.
Plants: Brooklyn N.Y. · Groton, Conn. · Tilton, N.H. · Los Angeles, Cal.

between the plates and the gear faces. Pumps have heavy-duty bearings, rotary shaft seals which eliminate pressure bleed-back, and antifriction roller bearings which carry a 1500-psi load at speeds up to 2000 rpm. Unidirectional rotation provides large inlet ports, and port connections are made by means of new SAE split flange hose connections. Made by Hydreco Div., **New York Air Brake Co.,** 1100 E. 222nd St., Cleveland 17, O.

For more data circle MD-113, Page 227

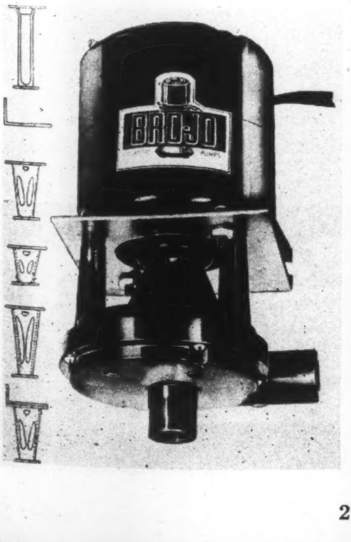
Phosphatizing Compound

Fosbond 61 produces fine crystalline phosphate coating which serves as base for subsequent painting operations. Developed for use on zinc surfaces, product can also be used on steel. Compound is applied by spraying after mixing with water. Formulated by **Pennsylvania Salt Mfg. Co.,** 1000 Widener Bldg., Philadelphia 7, Pa.

For more data circle MD-114, Page 227

Plastic Pump

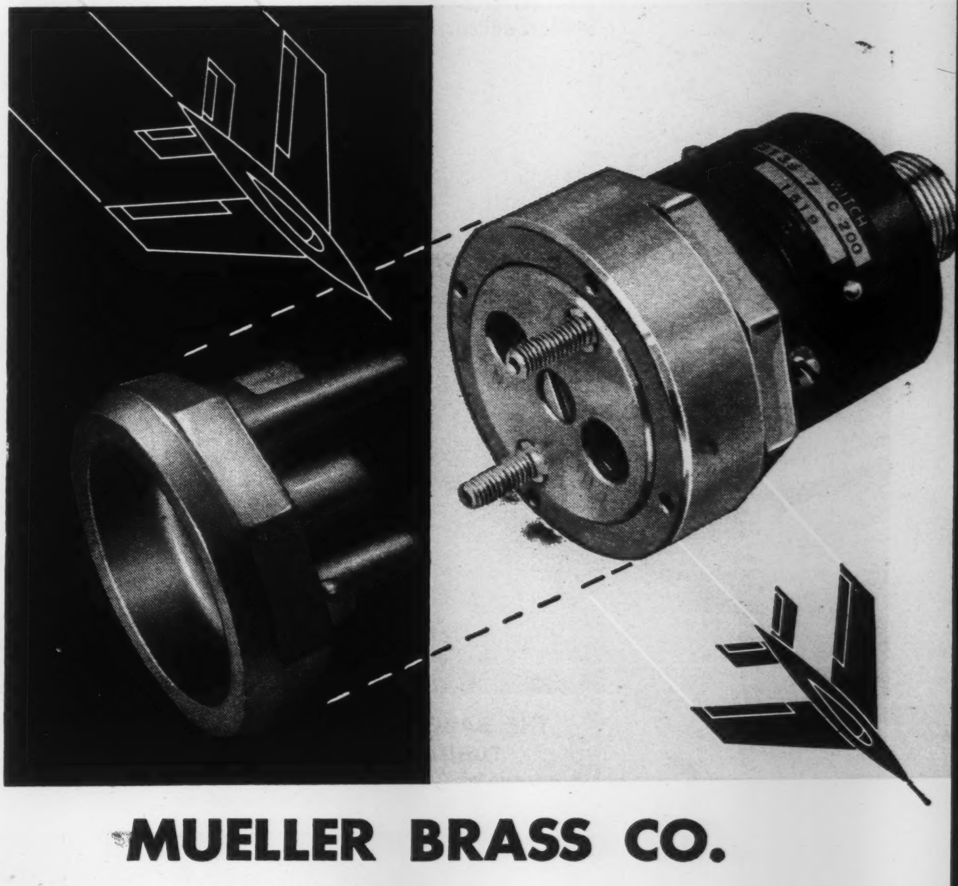
Six different standard mounting brackets are available for the plastic Bro-Jo centrifugal circulating pump. It is molded from phenolic thermosetting plastic that resists chemical action and has low water absorption. Horizontal or vertical mounting and standard motors ranging from 1/80 to 1/10-hp adapt it to a wide range of applications. Hard gloss finish on



MUELLER BRASS CO. forgings help insure dependable operatio of aircraft pressure warning instruments

A specially designed housing, accurately forged to customer specification by Mueller Brass Co., seals in the diaphragm of the pressure warning uni manufactured by Eclipse-Pioneer Division of Bendix Aviation Corporatio in Teterboro, New Jersey. The unit, designed for installation in fuel, oil, water or alcohol lines of modern aircraft is a highly sensitive instrument tha instantly warns the pilot or flight engineer of any unusually high or lo fluid pressures.

All Mueller Brass Co. forgings have a dense, close-grained structure with high tensile strength. Weight savings up to 40% are possible in the desig of parts because of the close tolerances to which they can be produced. Les scrap and longer tool life result from the easy machinability of forged parts. Mueller Brass Co. is completely equipped to design parts for your products, specify alloys (including special alloys developed by our metallurgists), forge, machine, finish and plate the parts and perform all necessary assembl operations. Write today for our free illustrated 32-page forgings catalog an complete information about MBCo forged parts for your products.



MUELLER BRASS CO.

PORT HURON 15, MICHIGAN

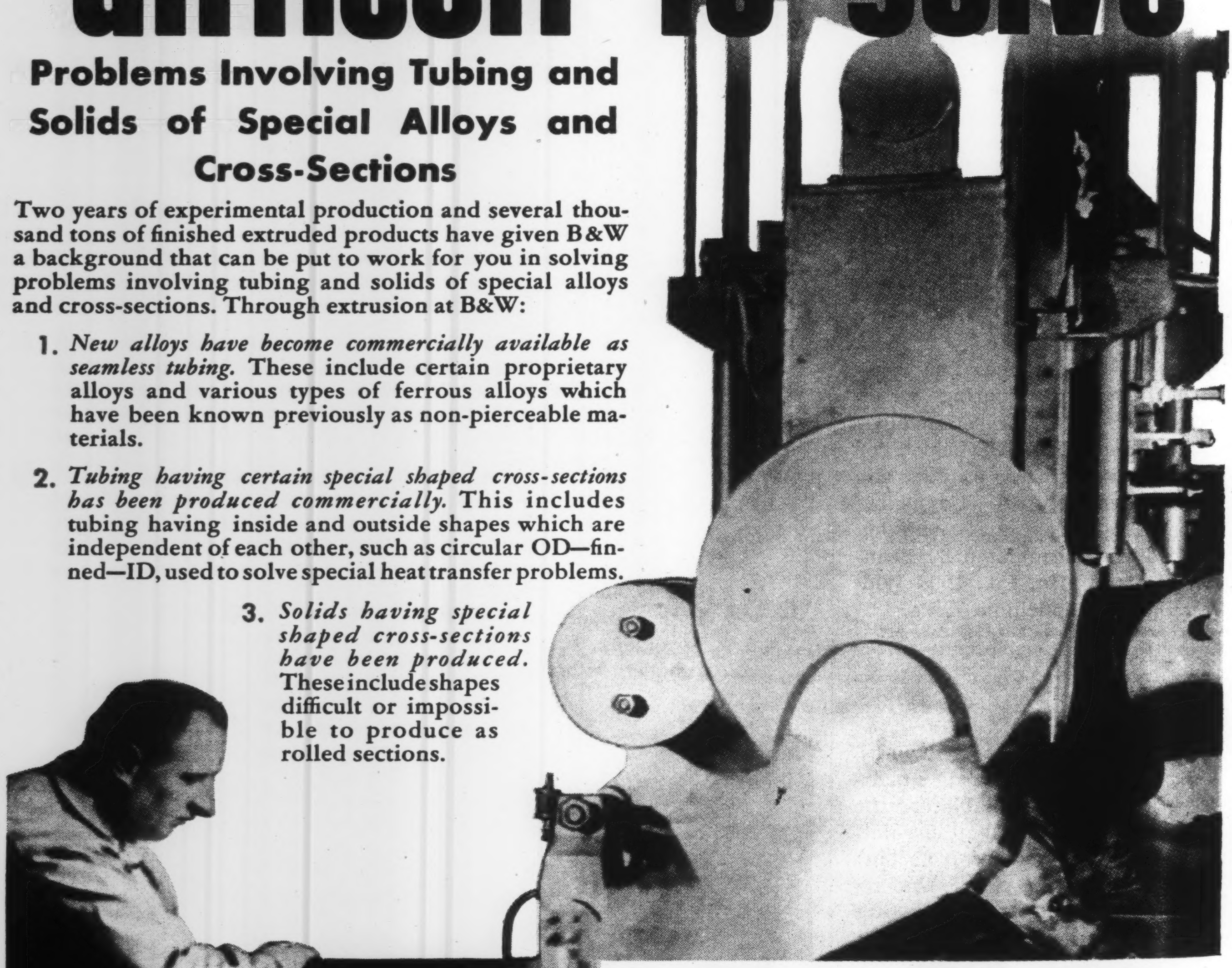
let us take a close look at your

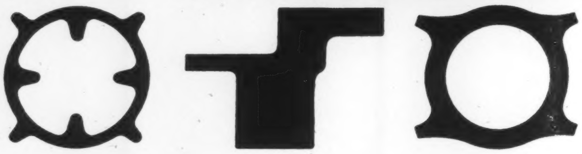
"difficult to solve"

Problems Involving Tubing and Solids of Special Alloys and Cross-Sections

Two years of experimental production and several thousand tons of finished extruded products have given B&W a background that can be put to work for you in solving problems involving tubing and solids of special alloys and cross-sections. Through extrusion at B&W:

1. *New alloys have become commercially available as seamless tubing.* These include certain proprietary alloys and various types of ferrous alloys which have been known previously as non-pierceable materials.
2. *Tubing having certain special shaped cross-sections has been produced commercially.* This includes tubing having inside and outside shapes which are independent of each other, such as circular OD—finned—ID, used to solve special heat transfer problems.
3. *Solids having special shaped cross-sections have been produced.* These include shapes difficult or impossible to produce as rolled sections.





Through extrusion, Mr. Tubes, your local B&W Tubing Representative, has helped others to solve problems involving tubing and solids of special materials and cross-sections. Call on him if you have such problems; chances are he will be able to help you.

TA-4031(X)

THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION
Beaver Falls, Pa.—Seamless Tubing; Welded Stainless Steel Tubing
Alliance, Ohio—Welded Carbon Steel Tubing

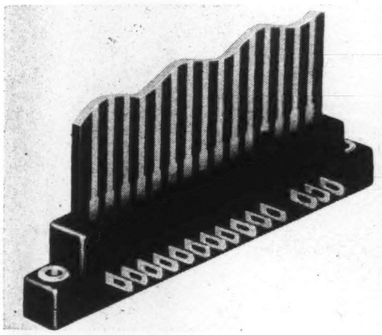
B&W SEAMLESS and WELDED TUBES

impeller and housing minimizes fluid friction and prevents build-up of hard water alkalines on the surfaces. Made by **Broadbent-Johnston Inc.,** 6845 E. Compton Blvd., Compton 2, Calif.

For more data circle MD-115, Page 227

Card Receptacles

Printed circuit card receptacles series 3370 and 3371 have enclosed contact tips and positive pressure-type contacts. Receptacles accommodate up to 15 gold over silver-plated beryllium copper contacts.



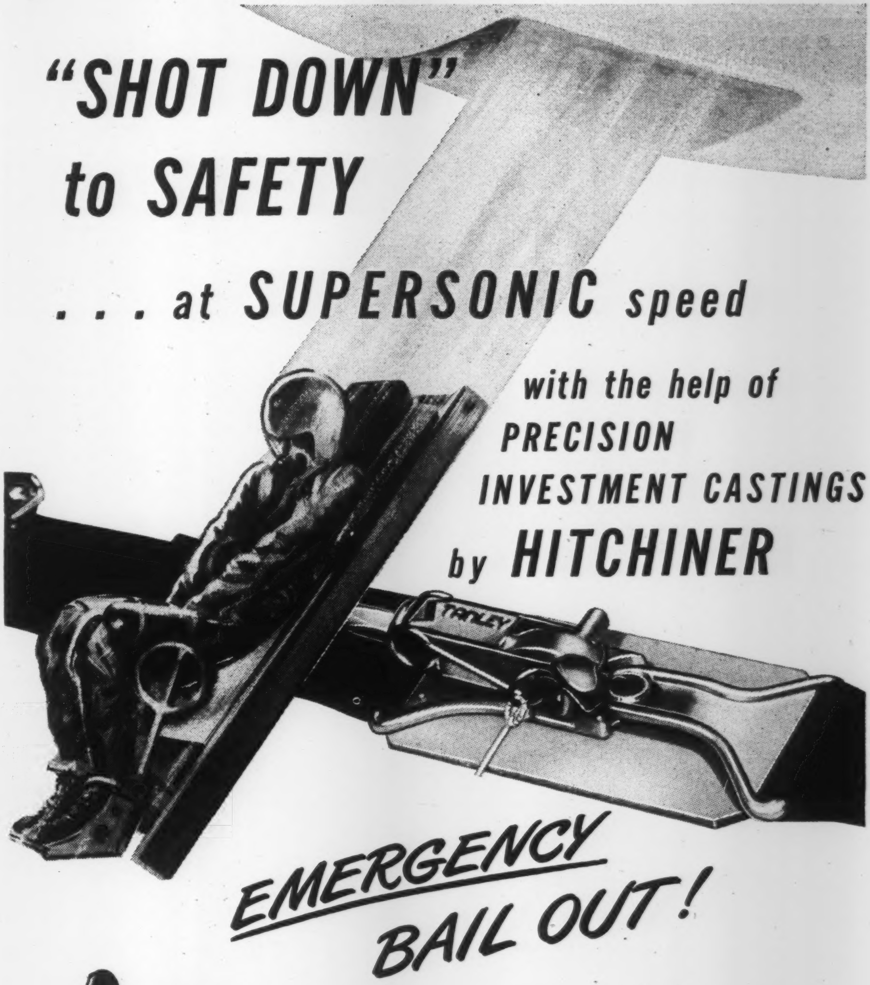
Wire connector tabs in series 3370 can extend from the right, left, or bottom of connector, or, in combinations of right, left, and bottom as desired. Series 3371 is available with terminals at bottom only for card thickness of 1/16, ⅛ and ¼-in., mounting by means of quick solder dip assembly. Nominal creep is 3/32-in. Standard connector is 3700 green mineral-filled phenolic; other materials are available. Made by **H. H. Buggie Inc.,** 726 Stanton St., Toledo 4, O.

For more data circle MD-116, Page 227

Photosensitive Aluminum

Metalphoto anodized aluminum sheets are used to produce such products as nameplates, dial and watch faces, wiring diagrams, instructions, and instrument scales. Photographs and drawings are processed from ordinary photographic negatives using standard

(*Continued on Page* 284)


"SHOT DOWN" to SAFETY
. . . at SUPERSONIC speed
with the help of PRECISION INVESTMENT CASTINGS by HITCHINER
STANLEY
EMERGENCY BAIL OUT!

And at sound-barrier speeds, a revolutionary bailout technique had to be found.

So engineers at Stanley Aviation Corp., Buffalo, N.Y., developed an ejection seat that catapults ***downward*** *from a plane and a lap belt that automatically opens, frees the airman from the seat, and sequences parachute opening.*

The cost of this priceless protection? Slashed to a minimum through the use of HITCHINER Precision Investment Castings. By combining several small parts into one . . . building complex shapes without added machining . . . using beryllium copper and stainless steel, HITCHINER achieved lower total production costs plus lighter weight with extra strength — economies and design achievements not possible with other production methods.

For a new approach — the logical solution to ***your*** *small parts problems — consult HITCHINER. Send us your drawings. Mail the coupon for informative FREE booklet.*

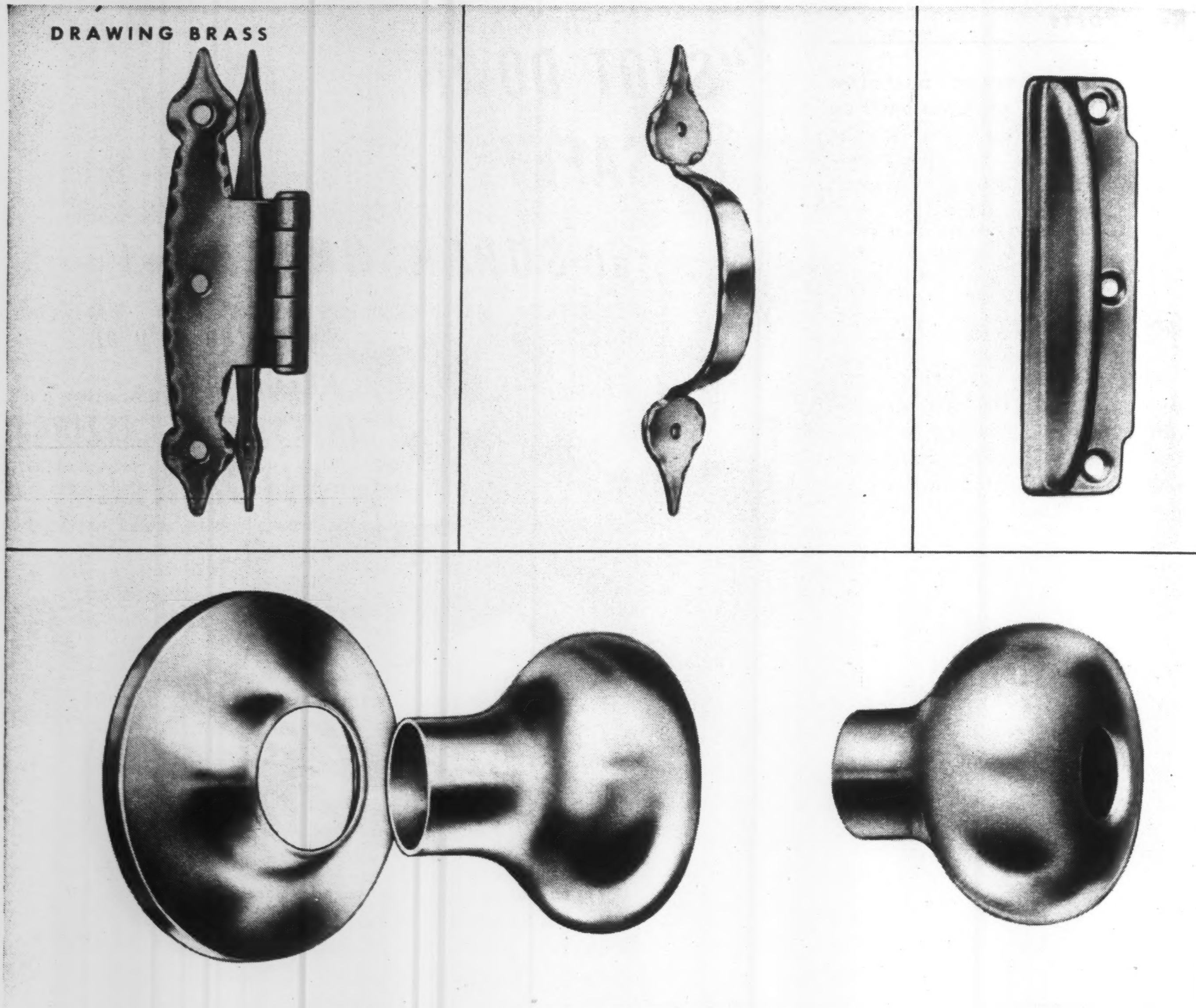
HITCHINER
Manufacturing Co., Inc.
MILFORD,
NEW HAMPSHIRE
SEE US AT BOOTH
# 1412
NATIONAL METAL
EXPOSITION
NOV. 1-5, CHICAGO

HITCHINER MFG. CO., INC.
MILFORD 8, NEW HAMPSHIRE

☐ *Send me your FREE booklet, "Investment For Economy . . . For Performance."*

☐ *Have your representative call.*

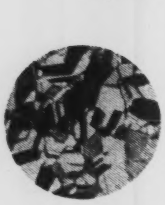
MY NAME____________________
POSITION____________________
CO. NAME____________________
CO. ADDRESS____________________
CITY__________ZONE________STATE________



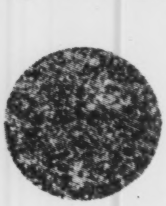
THESE HARDWARE ITEMS are made by Adams Rite Mfg. Co., Glendale, Cal., and National Lock Co. and American Cabinet Hardware Co., both of Rockford, Ill. They are typical of the stamped, drawn and pressed products

Formbrite—Anaconda's new drawing brass—polishes up to

Superfine grain makes Formbrite harder, stronger, springier and more scratch-resistant



75X magnification of ordinary drawing brass.



75X magnification of superfine-grain Formbrite.

Here is what enthusiastic manufacturers of stamped and drawn brass products say about *Formbrite:*

". . . cuts our polishing costs up to 50% . . . eliminates some finishing operations entirely . . . gives amazingly sharp die impressions . . . resists scratching in handling . . . plates beautifully . . . gives a more lustrous finish . . ."

Yet *Formbrite** costs no more than the ordinary drawing brasses these manufacturers had been using. In fact, Formbrite very often saves more than the metal itself costs.

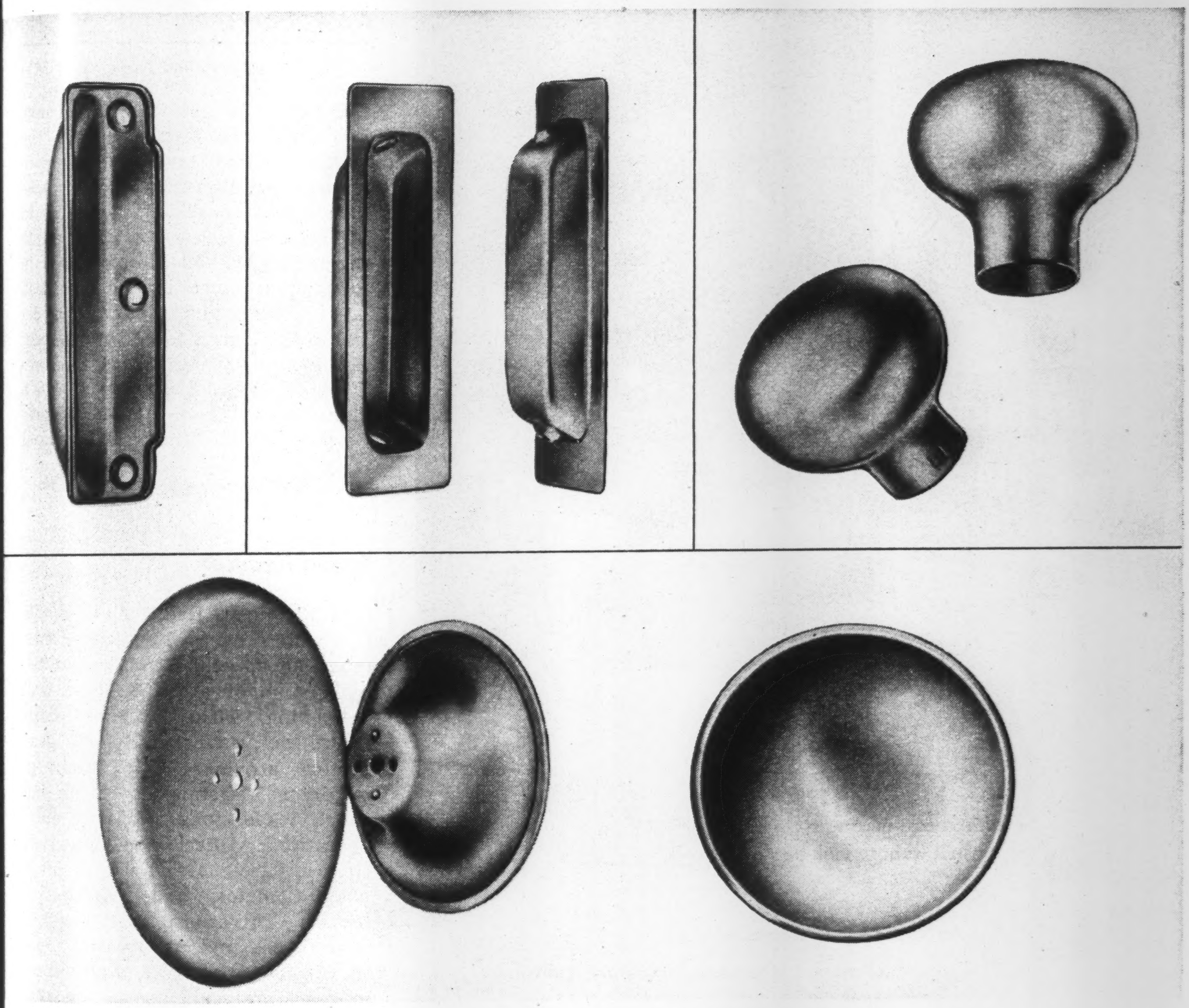
Why Formbrite is easier to use

Note Formbrite's superfine grain structure. Compare it with that of ordinary drawing brass. Special methods of rolling and annealing produce a grain structure so fine that often a simple color buff will bring it to a bright, lustrous finish.

Formbrite is also harder, stiffer, springier and more scratch-resistant . . . yet it is surprisingly ductile, readily stamped, formed, drawn and embossed.

Typical case

The Adams Rite Mfg. Co. makes the flush pull shown in the upper right



successfully made of Formbrite. Others include: lipstick holders, fishing lures, automobile hubcaps, gage cases, trophy nameplates, pen caps, etc. (Doorknob parts in lower left illustration have been chromium plated.)

50% faster... costs no more than ordinary drawing brass

illustration above. For this and many other building hardware items, they use Formbrite. They report:

"Formbrite increases surface hardness and rigidity of the part . . .eliminates several polishing operations and reduces over-all costs. Our flush pull definitely has been improved in quality."

Free sample

Formbrite is available in sheet, strip and coils—in all commercial widths and gages. Millions of pounds of this superior drawing brass have been made, sold and satisfactorily fabricated.

Want more proof? Mail the coupon and we'll send you a sample of Formbrite. Try it in your polishing room. See for yourself how quickly and easily Formbrite polishes. 5488

*Reg. U. S. Pat. Off.

Formbrite

FINE-GRAIN DRAWING BRASS

AN ANACONDA® PRODUCT

MADE BY THE AMERICAN BRASS COMPANY

FREE SAMPLE—Test Formbrite Yourself

The American Brass Company, Waterbury 20, Connecticut
(In Canada: Anaconda American Brass Ltd., New Toronto, Ont.)

☐ Send me a free sample of Formbrite to try in my polishing room.
☐ Send me Publication B-39, giving forming and finishing suggestions.

NAME..

COMPANY..

STREET..

CITY..................................ZONE......STATE..............

CASTINGS
on the lighter side
by WELLMAN

To be sure you're getting top quality lightweight castings, you'll want to look for:

- An experienced manufacturer
- A product made under close laboratory control and inspection
- Competent designers to work with your engineers
- A wide range of specifications and alloys
- Production economy

And you won't have to look far . . . just get in touch with WELLMAN. We'll be happy to help you with your castings problem.

Catalog No. 53 on request.

Well-Cast MAGNESIUM, ALUMINUM AND BRONZE CASTINGS
Well-Made WOOD AND METAL PATTERNS

THE WELLMAN BRONZE & ALUMINUM CO.
Dept. 10, 12800 Shaker Boulevard Cleveland 20, Ohio

New Parts

(*Continued from Page* 281)

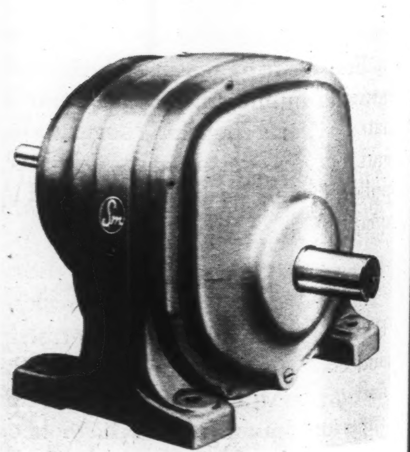
technique and solutions. The image is permanently sealed within the hard anodized layer which protects the dimensionally stable image from abrasion, heat up to 1000 F and acids, salts and organic solvents. The 50 billion pores in each square inch of the anodized layer permit almost limitless detail in the legend to be reproduced. Sheets are 0.020-in. thick and are available in 4 x 5, 8 x 10, and 10 x 12-in. sizes. Made by **Metalphoto Corp.**, 2903 E. 79th St., Cleveland 3, O.

For more data circle MD-117, Page 227

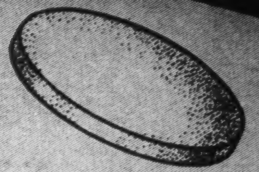
Speed Reducer

Multi-Mount Reducer, available in a wide range of horsepower ratings and speeds, can be mounted, without modification, on floor, wall or ceiling, with the shaft horizontal or vertical. Helical gear system provides high efficiency, maximum resistance to wear and shock loads, long life and quiet operation. Offset shafts permit compact designs and use of large gear diameters and require few parts. Driveshaft with widely spaced bearings is located close to the mounting feet, which minimizes torsional stress on the mounting base. Neoprene oil seals are used on the gear case, and a labyrinth seal is mounted on the input shaft. Gears run in an oil bath sealed in the gear case which acts as the oil reservoir. Made by **Sterling Electric Motors Inc.**, 5401 Telegraph Rd., Los Angeles 22, Calif.

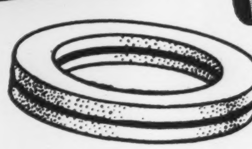
For more data circle MD-118, Page 227



American Felt Company can help you Reduce Costs... Improve Products

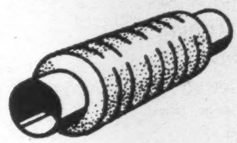


A glass-polishing plant had been purchasing felt discs 1½" thick. Changing to 2" at small extra cost effects appreciable economies. Increased disc life means longer runs without down-time for replacements.

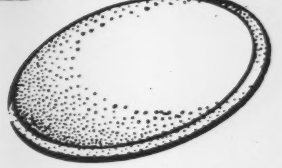


A popular household appliance originally had plain felt seals, held in place by complicated and expensive springs. Switching to Hycar-treated seals eliminated the springs, with consequent economy.

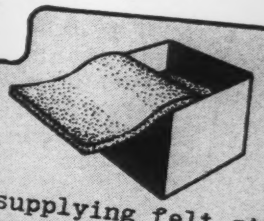
When you take advantage of the knowledge of your suppliers, as well as of their materials, you can often obtain cost-cutting advantages. Here are some recent examples of constructive collaboration between American Felt Company and its customers.



A large user of felt seals now receives them packed on cardboard tubes. The customer states this saves time in assembling.



A filter was re-designed to use fused edges, so that it could be delivered to the customer's plant ready for assembly without any processing whatever.



American was supplying felt strip in rolls. After examining the application, it was suggested that the felt be supplied in cartons, each containing 5,000 feet, the end brought out to the top of the carton, so one strip could be quickly joined to the end of the preceding one. Result: much time saved in replacing rolls.

Felt is an engineering material, available in many types. American's Engineering and Research laboratory is ready to work with you in selecting the most suitable and economical felt for your purposes. See the nearest Sales Office, or write direct.

American Felt Company

GENERAL OFFICES: [illegible], GLENVILLE, CONN.

SALES OFFICES: New York, Boston, Chicago, Detroit, Cleveland, Rochester, Philadelphia, St. Louis, Atlanta, Dallas, San Francisco, Los Angeles, Portland, Seattle, Montreal. PLANTS: Glenville, Conn.; Franklin, Mass.; Newburgh, N. Y.; [illegible]

AVON
Fusionweld
STEEL TUBING
Improves Performance Standards
Lowers Costs

LET US QUOTE ON YOUR TUBING AND FABRICATION NEEDS

Avon single wall steel tubing is successfully supplanting other types of tubing—aluminum, brass, copper and steel—with equal or improved reliability of performance and really impressive economies.

Avon's High Frequency Fusionweld process insures a much higher degree of tensile strength, greater resistance to vibration and fatigue, extreme ductility, plus greatly improved adaptability in producing the most critical tube forms—such as beading, bending, coiling, flaring, knurling, slotting, piercing, threading and swaging without cracking, tearing or checking.

Avon engineers can assist with your tubing problems and help point up cost saving advantages. Why not write, or submit blueprints for quotations.

AVON
FUSIONWELD
Steel Tubing
AVON TUBE DIVISION

3/16" O.D. to 3/4" O.D.
PLAIN OR TERNE COATED

A few of the hundreds of Fusionweld Tubing applications

AUTOMOTIVE
- Gas lines & vents
- Brake lines
- Hydraulic window & seat lifts
- Chassis tubes
- Radiator overflow
- Choke controls
- Oil return lines
- Dip stick tubes
- Oiler tubes
- Automatic transmission

FARM EQUIPMENT
- Hydraulic lifting devices
- Support tubes
- Lubrication lines
- Fuel lines
- Fuel manifolds

ELECTRICAL
- Ceiling & wall fixtures
- Lamp tubes
- Heating elements
- Radio & TV antennae

HEATING
- Oil & gas lines
- Pilot tubes
- Flash tubes
- Pot burner tubes
- Fuel tank tubes

TOYS—FURNITURE
- Scooter & wagon parts
- Spacers
- Pop guns
- Bicycle parts
- Mechanical toys
- Tables
- Chairs
- Swings
- Baby carriages, cribs, car seats and beds

MISCELLANEOUS
- Umbrellas
- Display boards
- Panels
- Conveyor oil lines
- Lawn mower handles
- Hose reels

AVON TUBE DIVISION

HIGBIE MANUFACTURING CO.

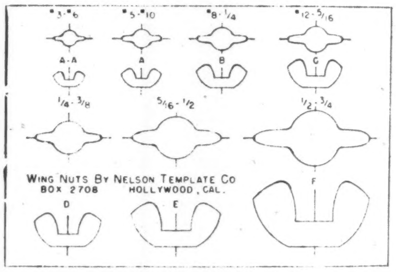
ROCHESTER MICHIGAN

ENGINEERING DEPARTMENT

EQUIPMENT

Drafting Templates

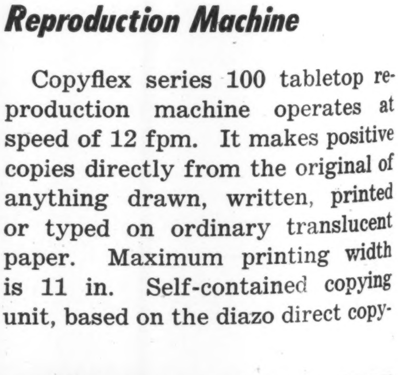
Templates made of cellulose acetate are offered in three styles. Wing nut template, illustrated, is 5½ x 8½ x 0.020-in. thick. Of identical dimensions, thumbscrew template has nine sizes of plain thumbscrews and seven sizes of shoulder type screws. Template for handknobs, with nine sizes, measures 8½ x 11 x 0.025-in. thick. Made by **Nelson Template Co.**, P. O. Box 2708, Hollywood 28, Calif.



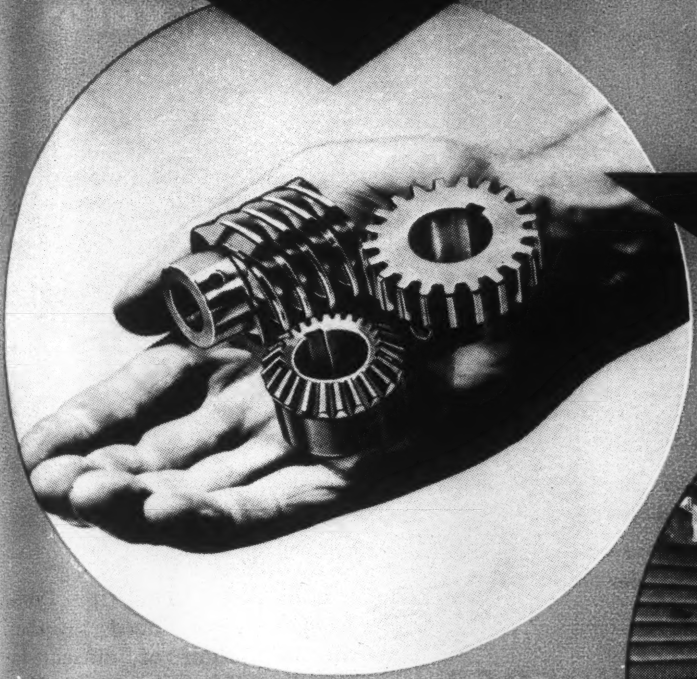
For more data circle MD-119, Page 227

Reproduction Machine

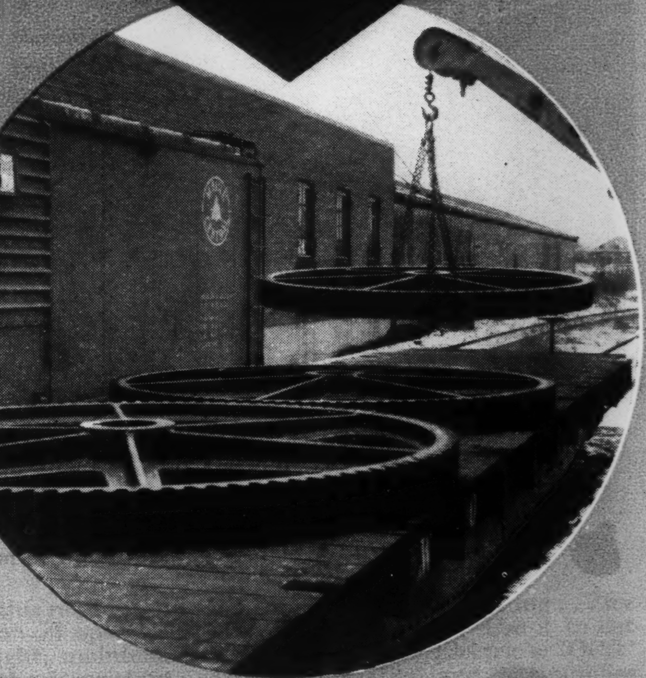
Copyflex series 100 tabletop reproduction machine operates at speed of 12 fpm. It makes positive copies directly from the original of anything drawn, written, printed or typed on ordinary translucent paper. Maximum printing width is 11 in. Self-contained copying unit, based on the diazo direct copy-



THREE GEARS TO A HANDFUL!



THREE GEARS TO A CARLOAD!



Gears for every purpose—from small precision gears to gears weighing 40 tons each or more. Whatever your needs, ILLINOIS GEAR makes the finest gears in the largest and best equipped plants to be found anywhere.

Whether you need three gears to the handful or three gears to the carload, get them at ILLINOIS GEAR.

Look for this mark ILL . . . the symbol on finer gears

ILLINOIS GEARS
Reg.U.S.Pat.Off.

Gears for Every Purpose ... one gear or 10,000 or more

ILLINOIS GEAR & MACHINE COMPANY

2108 NORTH NATCHEZ AVENUE • CHICAGO 35, ILLINOIS

WHY POWDER METALLURGY?

. . . Because Powder Metallurgy is the speedy, lower cost method of producing small metal parts with blueprint accuracy.

Parts may be so pressed and sintered that costly machining is eliminated or simplified.

Parts can be produced to close tolerances. For economy, there's no wasted metal—since die overflow powder can be reused.

WHY MD METAL POWDERS?

. . . Because nearly forty years of research and manufacturing experience have made MD the Headquarters for highest quality Metal Powders for every Powder Metallurgy need.

MD, the pioneer Metal Powder producer, is the *only* company producing *a complete line* of powders of such a wide range of metals and their alloys.

Remember
One Call
Does It All!

MD PRODUCTS
METAL POWDERS
METAL PIGMENTS
METAL ABRASIVES
Since 1916

3127

METALS DISINTEGRATING COMPANY, INC.
Elizabeth B, New Jersey
Plants:
Elizabeth, N. J.; Manchester, N. H.;
Berkeley, Calif.; Emeryville, Calif.

SUBSIDIARY OF AMERICAN-MARIETTA COMPANY

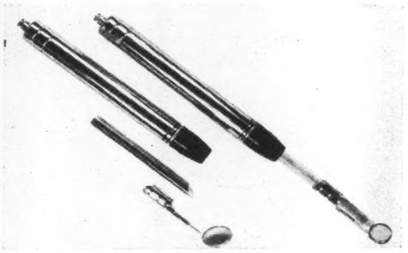
WORLD'S LARGEST MANUFACTURER OF FINELY DIVIDED METALS

ing process, does not require exhaust ducts, darkroom facilities, special lighting or plumbing. Made by **Charles Bruning Co. Inc.**, 4700 Montrose Ave., Chicago 41, Ill.

For more data circle MD-120, Page 227

Inspection Light

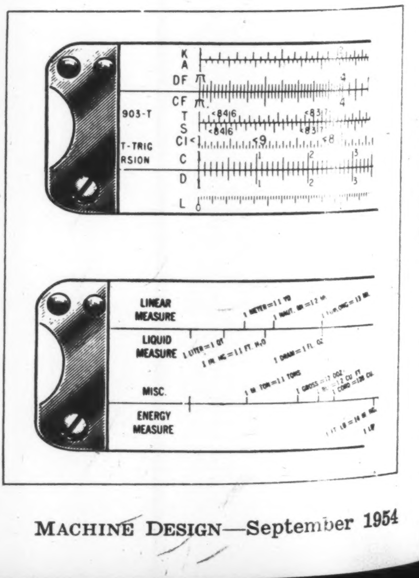
Inspection light combines light source, probe and mirror for around-corner inspection. Probe directs light beam to its tip. Probe and $1\frac{1}{2}$x mirror, used together, permit inspection of difficult-to-reach areas. Made by **Moore Mfg. Co.**, Swedesboro, N. J.



For more data circle MD-121, Page 227

Conversion Slide Rule

Conversions involving energy, linear and liquid measurement and other factors are made with one setting of 903-T conversion rule. One side of the rule has 64 linear, liquid, energy and miscellaneous factors; reverse side has a complete trigonometric scale arrangement



AUTOMATIC
SWITCHES
RELAYS
ELECTRIC
RELAYS
AUTOMATIC ELECTRI
SWITCHES
RELAYS
MATIC ELECTRIC
SWITCHES
RELAYS
AUTOMATIC ELECTRIC
SWITCHES
RELAYS
MATIC ELECTRIC
SWITCHES
RELAYS
AUTOMATIC
SWITC
RIC
RELAYS
AUTOMATIC ELECTRIC
SWITCHES
AUTOM

COMBINE
relay and stepping switch functions

. . . with this **one** **cam-type** relay

specify contact sequences to fit the job

HELPFUL ENGINEERING INFORMATION

cams—Each revolution is divided into 36 steps—any combination of "operated" or "unoperated" intervals can be provided.

contact arrangement—Maximum of 6 contact springs for each of the 3 cams.

spring contacts—Twin contacts. Will make and break load of 150 watts (maximum 3 amps.). "Heavy-duty" single contacts can be provided for higher wattage.

speed of operation—Self-interrupted, 65 steps per second; impulse-controlled, 35 steps per second.

vibration—Withstands up to 10.5 G.

shock and acceleration—Up to 25 G.

ambient temperatures—From –55°C. to +75°C.

weight—14-20 oz.

size—3 1/4" x 2 7/16" x 1 25/32".

You plan this relay's programming . . . for cam-switching . . . for alternate on-off operations . . . or as a "stepper." Use it to cut space, weight, maintenance costs. Automatic Electric's "OCS" Relay is shock-resistant, compact, versatile, and it simplifies engineering—

cam-switching—Use this rugged unit to replace entire banks of relays and switches. You can really count on it to work—*performance records exceed 250,000,000 high-speed operations!*

alternate on-off operations—Replace delicate latch-in type relays with dependable "OCS" units. You can expect excellent service even under extreme conditions of shock, vibration, and temperature change.

stepping operations—Stepping is high-speed, accurate and dependable. The relay can be driven self-interruptedly to produce a time cycle or for "homing." You can extend the range of your present planning with complete facts on this outstanding addition to an outstanding line of quality relays—write today to: Automatic Electric Sales Corporation, 1033 West Van Buren Street, Chicago 7, Illinois. In Canada: Automatic Electric Sales (Canada) Ltd., Toronto. Offices in principal cities.

RELAYS PRODUCTS OF THE INDUSTRIAL DEPARTMENT OF **SWITCHES**

AUTOMATIC ELECTRIC®

CHICAGO

SHENANGO Centrifugal CASTINGS ... KEY TO SAVINGS

Precision-machined by Shenango for paper making machinery are these two centrifugally cast bronze wire stretch rolls with Meehanite Metal heads and steel journals. Note the special water slinger ring on the head.

Shenango methods ...Your gain!

SHOWN above are 15-foot wire stretch rolls of centrifugally cast bronze. From end to end, inside and out, these and all Shenango centrifugal castings are uniform in high quality.

The carefully controlled centrifugal casting process developed by Shenango assures exceptionally fine pressure-dense grain and freedom from costly imperfections. For you, these features mean trouble-free performance and wear resistance, minimum maintenance, and the ability to withstand abnormal loads and speeds. Yes, increased savings from every angle.

Shenango is prepared to supply either rough castings, semi-machined or precision-finished parts and assemblies in either ferrous or nonferrous metals. For further information and data on meeting specific needs, write to . . .

SHENANGO-PENN MOLD COMPANY
Centrifugal Castings Division
Dover, Ohio
Executive Offices: Pittsburgh, Pa.

SHENANGO

COPPER, TIN, LEAD, ZINC BRONZES • MONEL METAL
ALUMINUM AND MANGANESE BRONZES • NI-RESIST • MEEHANITE METAL

consisting of A, K, DF-CF, T, S, CI, C-D and L scales. Positioning a conversion mark opposite an index mark sets any conversion on the C, D, CF or DF scales without moving the slider and without further computation. Automatic conversion principle is adaptable to any set of specialized conversion factors on either pocket-size or 10-in. rules. Made of lightweight, corrosion-resistant metal alloy with white facing, rule is 12⅛ x 1¼ x 3/32-in. and weighs 2¾ oz. Made by **Pickett & Eckel Inc.,** 1109 S. Fremont St., Alhambra, Calif.

For more data circle MD-122, Page 227

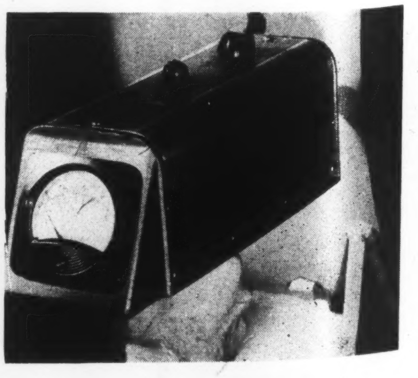
Drafting Tape

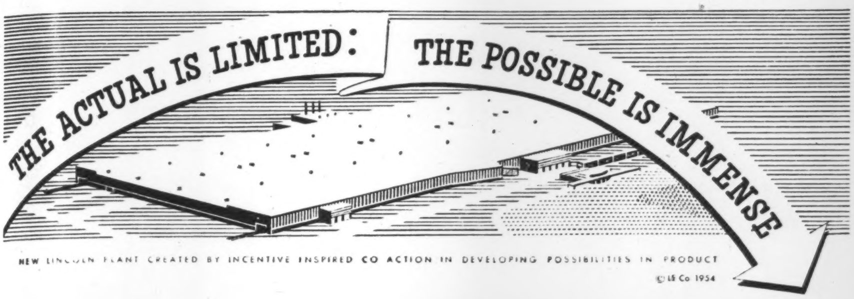
Available in 17 standard widths ranging from ¼-in. to 3 in., Behr-Cat No. 114 pressure-sensitive drafting tape holds tracing paper or cloth firmly on drafting or drawing boards, unrolls cleanly and leaves no defacing or discoloring marks on the drawing paper or cloth. It also resists breaking off during unrolling and application but tears readily across its width. Tape is packaged in 60-ft rolls. Made by **Behr-Manning Corp.,** Troy, N. Y.

For more data circle MD-123, Page 227

Portable Vibration Meter

Model VHA direct-reading portable vibration meter measures displacement and acceleration. It operates over a frequency range of 10 to 250 cycles per second; acceleration ranges of 0 to 0.03, 0 to 0.10, 0 to 0.30, 0 to 1, 0 to 3, and




THE ACTUAL IS LIMITED: THE POSSIBLE IS IMMENSE
NEW LINCOLN PLANT CREATED BY INCENTIVE INSPIRED CO ACTION IN DEVELOPING POSSIBILITIES IN PRODUCT
© LE Co 1954

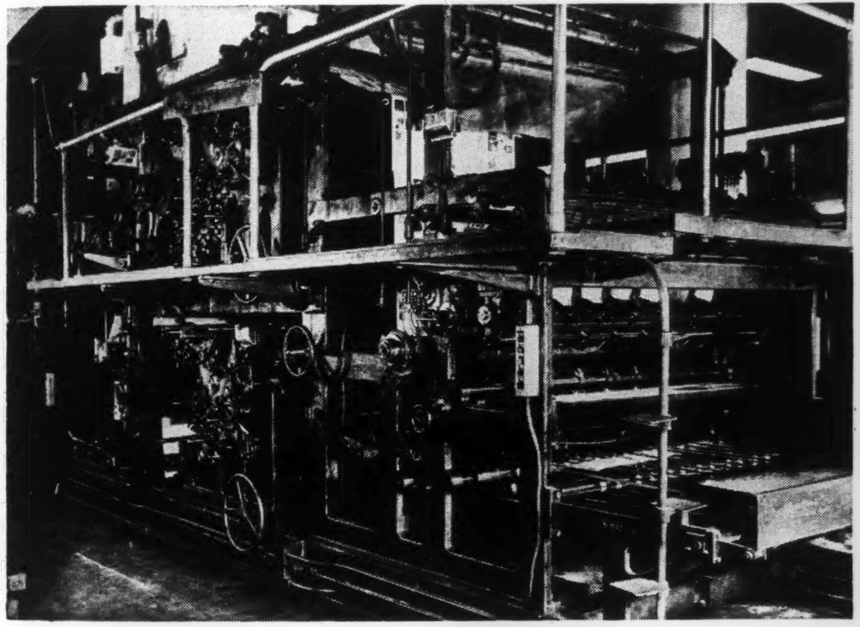


Fig. 1. Saves $560.00 per frame *by converting to welded steel design. Weight is cut from 405 to 300 pounds per frame.*

WELDED DESIGN REDUCES VIBRATION

improves accuracy...while cutting costs

CONTRARY to traditional belief, high speed machinery like printing presses can be made from welded steel to run faster, smoother with minimum adjustment for register.

This 75 foot welded steel press built by Goss Printing Press Company for a popular magazine publisher runs at 11,500 impressions per hour compared to 4,000 by the press it replaced. Yet, vibration is less, make-ready is faster, fewer adjustments are needed.

The main top and bottom frames are all welded steel as are cross members. The design is clean . . . easy to maintain, simplifying upkeep.

Savings in cost are up to 50% compared to former cast designs.

HOW TO CREATE COST REDUCTIONS THROUGH DESIGN

Machine design sheets showing how to simplify design, save metal and cut costs are available to product engineers and designers by writing on your letterhead.

SAVES METAL CUTS COST 50%

When products are properly designed in welded steel, cost savings average 50% because:

1. Steel is 3 times stronger than gray iron.
2. Steel is 2½ times as rigid.
3. Steel costs a third as much as iron.

Ultimate savings are limited only by the ingenuity of the designer.

By converting machine components from castings to welded steel, greater strength and increased rigidity are often attained at substantial reductions in cost. For example:

The housing for the folder frame on this Goss Printing Press (Figure 1) previously weighed 405 pounds . . . cost $683.00. The welded steel frame weighs only 300 pounds, costs only $123.00 . . . *an 84% reduction in cost.*

One of two uprights once weighed 3,903 pounds . . . cost $1,600.00. The weldment now replacing the cast unit weighs 3,000 pounds . . . costs $1,070.00 . . . saving $530.00 on each upright.

The folder bed plate (Figure 2) was a 4,113-pound casting and cost $1,725.00 to cast and machine. The welded bed plate now used weighs 3,000 pounds and costs only $248.00.

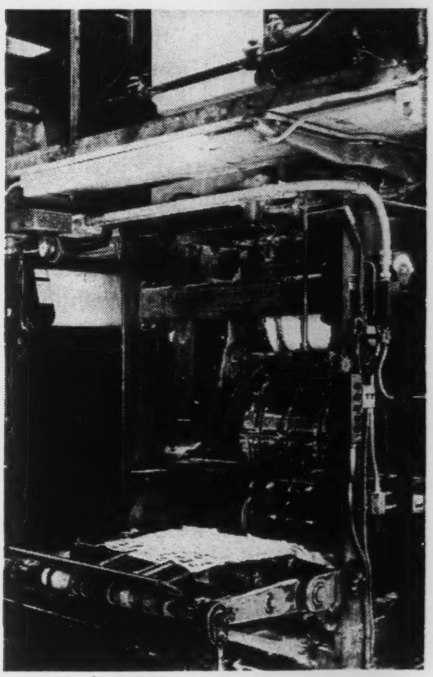


Fig. 2. Saves 1,113 pounds . . . *cost down 86% on press folder bed plate.*

THE LINCOLN ELECTRIC COMPANY

DEPT. 1106 • CLEVELAND 17, OHIO

THE WORLD'S LARGEST MANUFACTURER OF ARC WELDING EQUIPMENT

Specify

WHERE PRECISE MEASUREMENT OF TIME IS ESSENTIAL . . .

Cramer RUNNING TIME METERS

"The Cramer running time meter plays an extremely important part in our equipment . . . ," reports R-C Scientific Instrument Company, Inc., Playa Del Rey, California, manufacturers of high-quality radiation detection instruments.

"The *Scintiscaler* shown here is designed for alpha, beta or gamma counting interchangeably. The quoted accuracy of our apparatus is based on a statistical formula for computing the probable error in sampling a series of pulses randomly spaced in time. Since no allowance is made in this formula for the running time meter, it must be extremely accurate. *We've used Cramer devices on all our scalers for the past five years with no failures.*"

Regardless of application or type of timing device needed, it will pay you to consult the R. W. Cramer Company, *specialists in time control.* An experienced engineering staff is available to help you solve your timing problems.

Running time meter with reset feature for flush panel mounting. Complete line of time control equipment available to fit every installation requirement.

Cramer TIMING DEVICES

SPECIALISTS IN TIME CONTROL

The R. W. CRAMER CO., Inc.

BOX 6, CENTERBROOK, CONNECTICUT

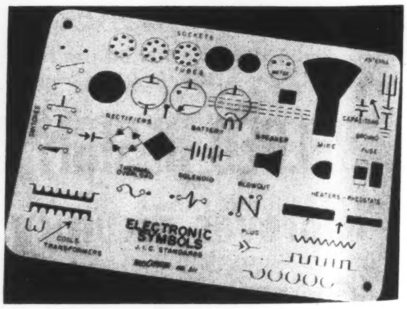
11CR54

0 to 10 g; and peak-to-peak displacement ranges of 0 to 3, 0 to 10, 0 to 30, 0 to 100 and 0 to 300 mils full scale. Meter consists principally of a barium titanate accelerometer, which feeds through an electronic amplifier and a copper-oxide rectifier to an indicating microammeter. Operation is not affected by magnetic fields. Instrument is powered by hearing aid batteries and has a pistol-grip, trigger type switch. It is 4 x 8 x 13¾ in.; weighs about 5 lb. Made by Meter and Instrument Dept., **General Electric Co.,** Schenectady 5, N. Y.

For more data circle MD-124, Page 227

Electronic Symbols Template

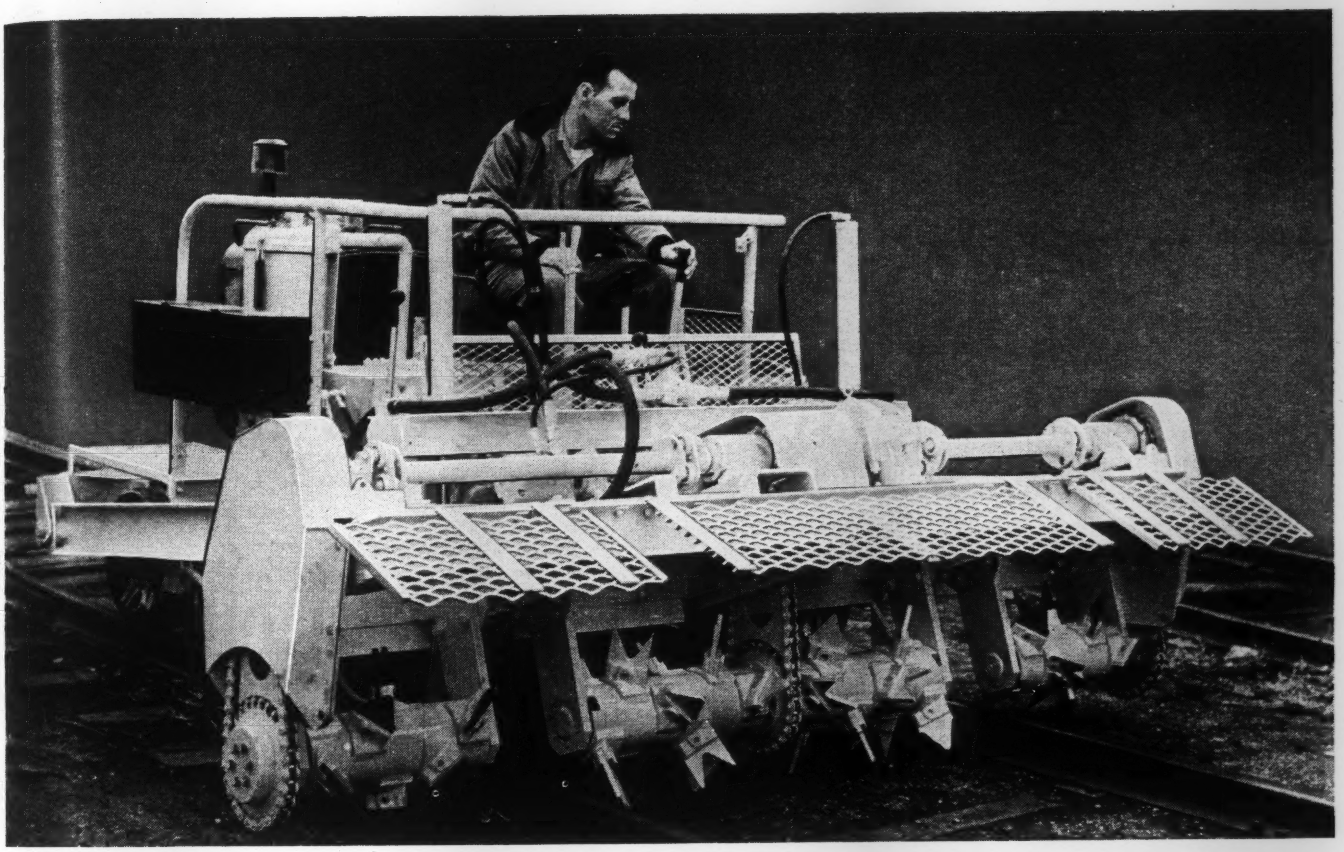
No. 311 template contains JIC standard symbols for the industrial electronic, television, radio and electrical fields. Made of matte finish plastic, it has milled cutouts. Size of template is 5 x 7 x 0.030-in. thick. Made by **Rapidesign Inc.,** P. O. Box 592, Glendale, Calif.



For more data circle MD-125, Page 227

Scaled-Line Meter

Minerva Curvimeter records blueprint scale footage on straight or curved lines. Three footage registers on instrument's dial face record distances of up to 2400 ft on blueprints scaled ⅛-in. to 1 ft; 1200 ft on prints scaled ¼-in. to 1 ft; and 600 ft on drawings scaled ½-in. to 1 ft. A small hand centered in a dial on the main dial moves forward one division with each complete revolution of the



How Morse equipment helps increase output and efficiency of railroad tie renewal gangs

This complex machine helps railroads protect economically their prime asset, smooth roadbeds. With new Tie Bed Scarifier—produced by Fairmont Railway Motors, Inc.—one operator can dig a uniform tiebed ten feet long in a minute or less. This uniformity, aside from making the insertion of new ties easier, means even support for new ties after tamping, and insures mile after mile of level rail.

The above illustration shows how Morse Power Transmission equipment lends itself to tough design problems. Three Morse Roller Chain Drives and two Morse Flexible Coupling Driveshafts transmit power smoothly from the motor to the three digging drums, and perform efficiently, despite shock loading and abrasive dust from the impacted ballast.

Additional design advantages include: (1) increased drive center distance tolerances, (2) automatic compensation for torsional deflexion and misalignment between motor driveshaft and digging drums, (3) adaptability to the small lateral space available.

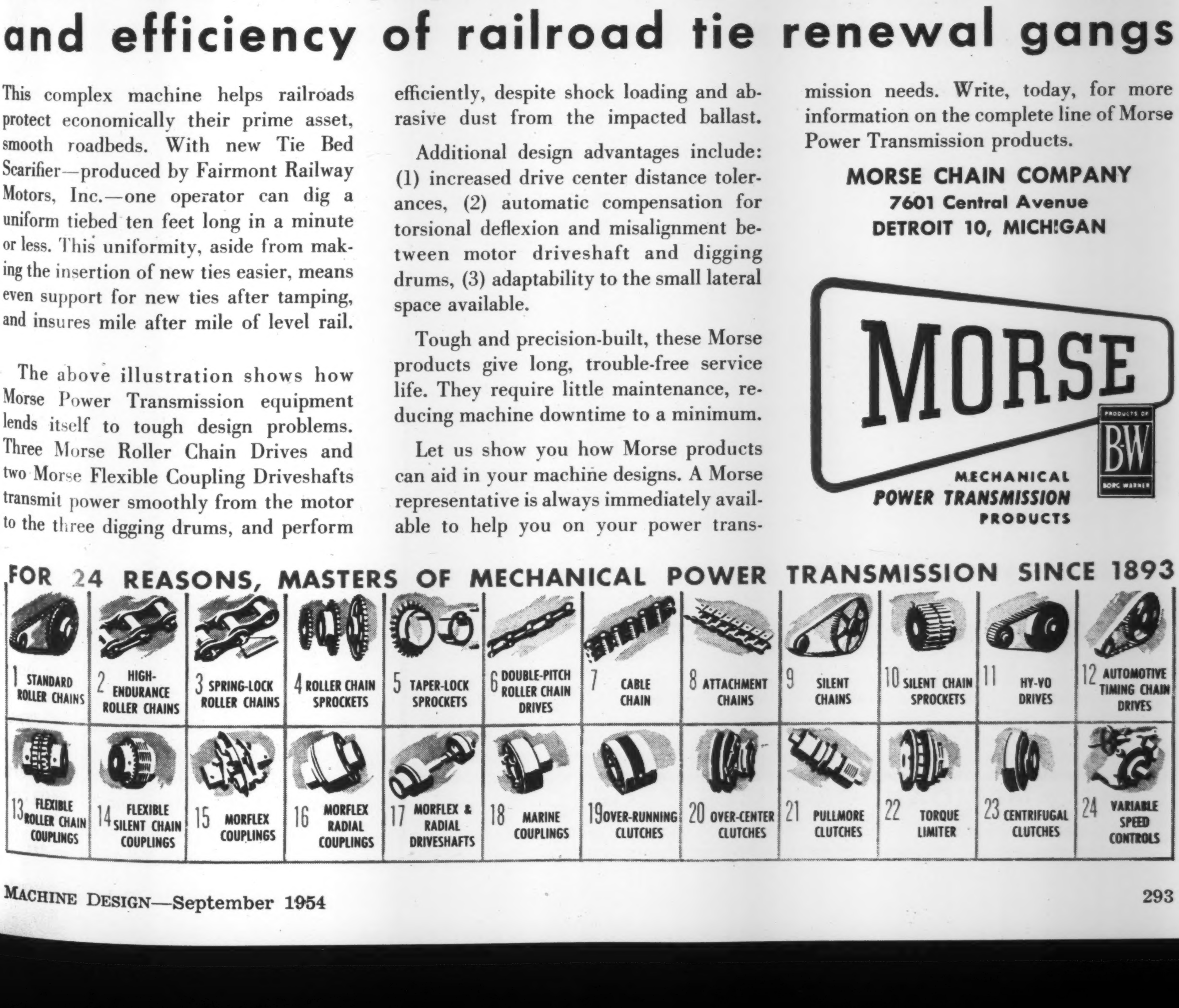
Tough and precision-built, these Morse products give long, trouble-free service life. They require little maintenance, reducing machine downtime to a minimum.

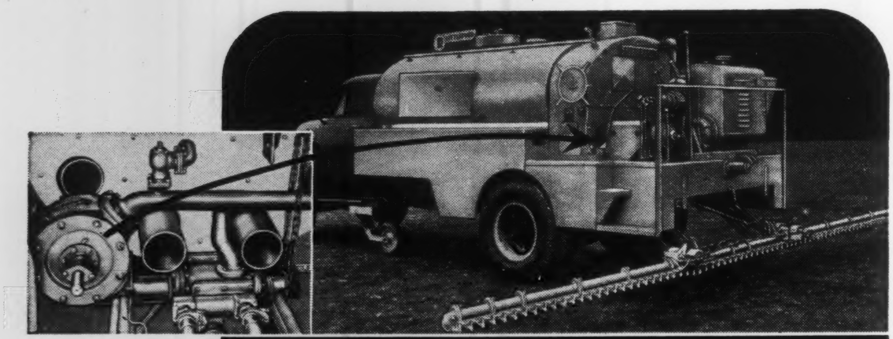
Let us show you how Morse products can aid in your machine designs. A Morse representative is always immediately available to help you on your power transmission needs. Write, today, for more information on the complete line of Morse Power Transmission products.

MORSE CHAIN COMPANY
7601 Central Avenue
DETROIT 10, MICHIGAN

MORSE
PRODUCTS OF
B-W
BORG WARNER
MECHANICAL
POWER TRANSMISSION
PRODUCTS

FOR 24 REASONS, MASTERS OF MECHANICAL POWER TRANSMISSION SINCE 1893


1 STANDARD ROLLER CHAINS
2 HIGH-ENDURANCE ROLLER CHAINS
3 SPRING-LOCK ROLLER CHAINS
4 ROLLER CHAIN SPROCKETS
5 TAPER-LOCK SPROCKETS
6 DOUBLE-PITCH ROLLER CHAIN DRIVES
7 CABLE CHAIN
8 ATTACHMENT CHAINS
9 SILENT CHAINS
10 SILENT CHAIN SPROCKETS
11 HY-VO DRIVES
12 AUTOMOTIVE TIMING CHAIN DRIVES
13 FLEXIBLE ROLLER CHAIN COUPLINGS
14 FLEXIBLE SILENT CHAIN COUPLINGS
15 MORFLEX COUPLINGS
16 MORFLEX RADIAL COUPLINGS
17 MORFLEX & RADIAL DRIVESHAFTS
18 MARINE COUPLINGS
19 OVER-RUNNING CLUTCHES
20 OVER-CENTER CLUTCHES
21 PULLMORE CLUTCHES
22 TORQUE LIMITER
23 CENTRIFUGAL CLUTCHES
24 VARIABLE SPEED CONTROLS



More than 20,000 VIKING PUMPS IN THE LAST 25 YEARS
on Littleford Bros. Equipment

YOU, too, can be assured of top pumping performance. Follow the example of Littleford Bros., Inc., Cincinnati. They know what Viking pumps can really do after incorporating over 20,000 of them on their road construction and maintenance equipment. Service includes handling hot or cold road oils, tars, asphalt, cutbacks and emulsions.

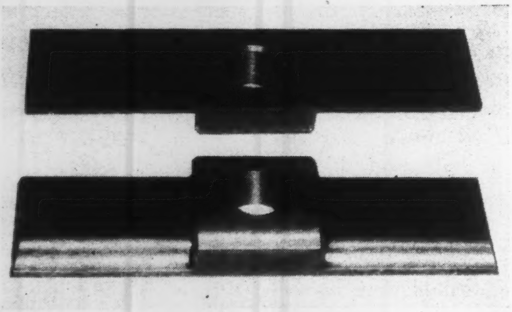
If you are looking for dependable pumps as original equipment, or for individual performance, follow Littleford's example and learn more about Vikings. Write for bulletin 54SH.

VIKING AN HONORED NAME IN PUMPING

See Our Catalog In SWEETS

VIKING PUMP COMPANY
CEDAR FALLS, IOWA

FOR A MONEY-BACK GUARANTEE OF LONGER SERVICE



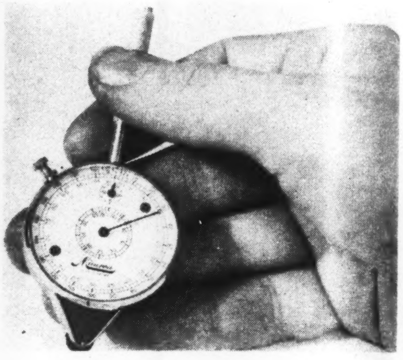
Specify PROMET THE Engineered BRONZE

BEARINGS-BUSHINGS WEARING PARTS

Sold only under a rigid guarantee of superior and satisfactory service or a refund of the purchase price upon return—the customer's opinion to be final.
Available in standard and special formulas developed to cope with specific or unusual conditions. Assure the best combination of physical properties, strength in tension and compression, hardness, and ability to sustain both static and dynamic loading.
Protect the shaft or other moving parts from injury, scoring, and seizing due to temporary interruption or failure of lubrication, and at the beginning and end of a run, when the speed of rotation is insufficient to maintain the oil film.
They will not powder under the most severe conditions of service. Available rough cast or machined to precisely controlled tolerances. They can be machined at surface speeds up to 875 lineal feet per minute.
Castings to your patterns—any size, shape or section—delivered as scheduled and specified. Pattern making, designing and machining when required.
Write today for free literature and service data sheets. Send blueprints, conditions of operation and other data for recommendations and quotations. You are invited to discuss your bearing problems with our metallurgists, engineers, and laboratory technicians.

THE AMERICAN CRUCIBLE PRODUCTS CO.
1321 Oberlin Avenue · Bearing Specialists Since 1919 · Lorain, Ohio, U. S. A.

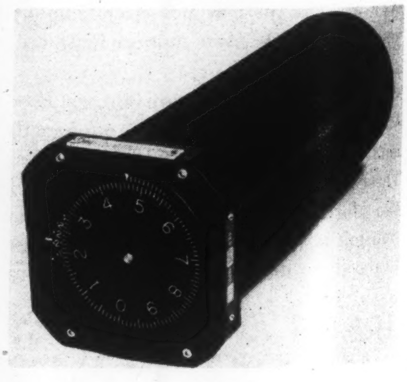
long hand. Both hands are returned to zero by light pressure on a lateral pushbutton. Contact wheel has twin-jewel mounting for accuracy and long life. Made by **M. Ducommun Co.,** 580 Fifth Ave., New York 36, N. Y.



For more data circle MD-126, Page 227

Data Repeating Systems

Data repeaters relay test data to remote stations and present the information in visual form on a dial which can be photographed. High accuracy is achieved under both static and dynamic conditions of operation. Instruments have a static accuracy of ±0.03-deg, a bandwidth of approximately 25 cycles per second, a velocity constant in excess of 13,000, a torque constant of 3000 oz-in./deg, and a maximum slewing speed of 3000 deg/second. Various models are available. Made by **Midwestern Geophysical Laboratory,** 3401 S. Harvard Ave., Tulsa, Okla.



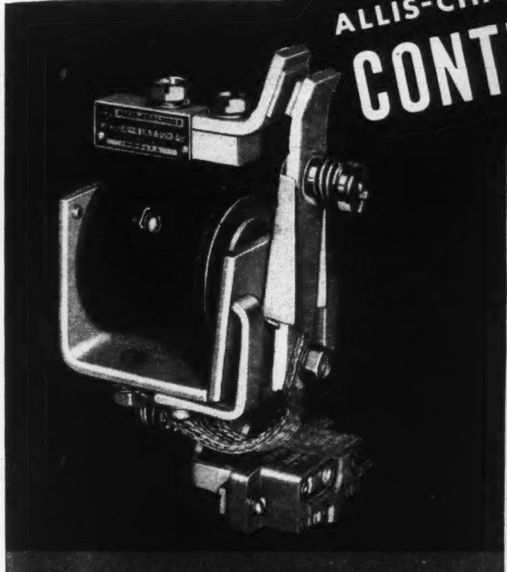
For more data circle MD-127, Page 227

Recently developed

DC CONTACTORS

ALLIS-CHALMERS
CONTROL

perform wide range of control functions



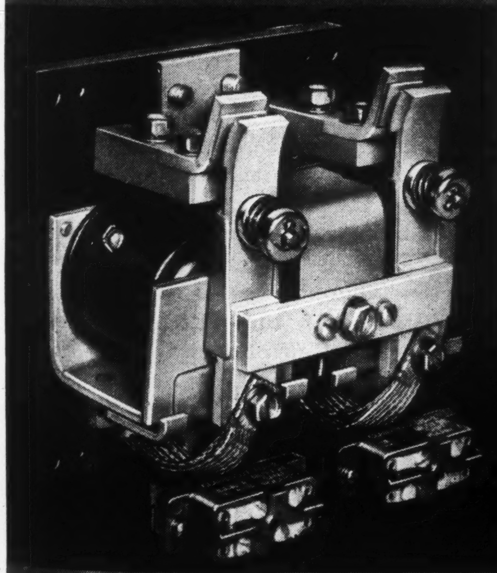
Type 264 single-pole general-duty contactor

Acceleration, reversing, timing, plugging, switching. Allis-Chalmers Type 264 can be used singly for any of these tasks. Group-mounted, they perform several or all of these functions. This versatility, coupled with a compact design, provides equipment manufacturers with a new measure of control flexibility. Performance-proved on electric industrial trucks, cranes and hoists, these dc contactors may be applied wherever dependable intermittent duty is essential . . . wherever installation space is at a premium. Type 264 contactors are rated 200 and 400 amps at 36 volts.

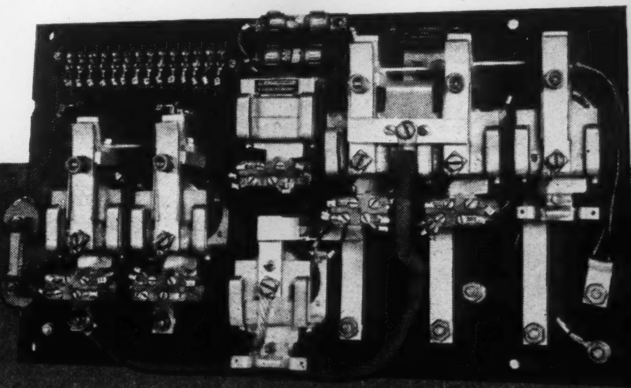
Check these advantages

Compactness has been achieved without sacrificing accessibility. All normal wearing parts can be removed from the front.

Other features . . . Silver plated current-carrying parts. Silver alloy contact tips. Extra flexible stranded shunts. Amply sized single-break contacts. Optional interlocks.



Type 264 reversing general-duty contactor



Panel shows how both single-pole and reversing contactors may be mounted to perform control functions.

A-4400

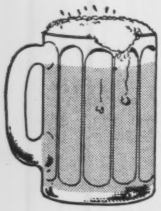
How to Be Sure You Get the Right Controls for Your Product

Type 264 contactors are typical of the standard, modified standard and special controls designed and produced by Allis-Chalmers.

When your products reach the drafting board stage, call in your A-C representative. He'll be glad to give you comprehensive engineering assistance. Backed by the Allis-Chalmers engineering, research and testing facilities, he's fully qualified to make suggestions which may help you get substantial savings in time, money and trouble.

For details, call your District Office or write Allis-Chalmers, Milwaukee 1, Wis.

ALLIS-CHALMERS



Everyone knows this
is a sign of refreshment...

And smart gear users know
this CINTI is the sign of
the best in custom made gears.

CINTI "Gears... Good Gears Only"

THE CINCINNATI GEAR CO. • CINCINNATI 27, OHIO

ILSCO
UL QUALITY CSA
CONNECTORS

LO 7 SIZES 1000 MCM – 14

SLU 11 SIZES 1000 MCM – 14

CAN NEUTRAL 60, 100 & 200 AMPS.

XT 6 SIZES 500 MCM – 14

FUSE CLIPS MANY SIZES AND TYPES

VT 6 SIZES 600 MCM – 14

TERMINAL BLOCKS LOK-A-BLOK

MU 3 SIZES 500 MCM – 6

WRITE FOR 80-PAGE CATALOG

ILSCO [illegible] MARIEMONT AVE., CINCINNATI 27, OHIO

Stress Relief

DESIGN is a creative activity with many satisfactions, but it also has its hazards. One of them—a physical hazard—was recently discussed by Trafford W. Bigger before the management division of the American Society of Mechanical Engineers.

Wasted Manpower

Many thinking people have observed in recent years the relatively large numbers of highly trained and intelligent men who, usually in the age range between forty and sixty, have suddenly cracked up or reached an untimely end. Their difficulty is very often reported as some form of heart disease.

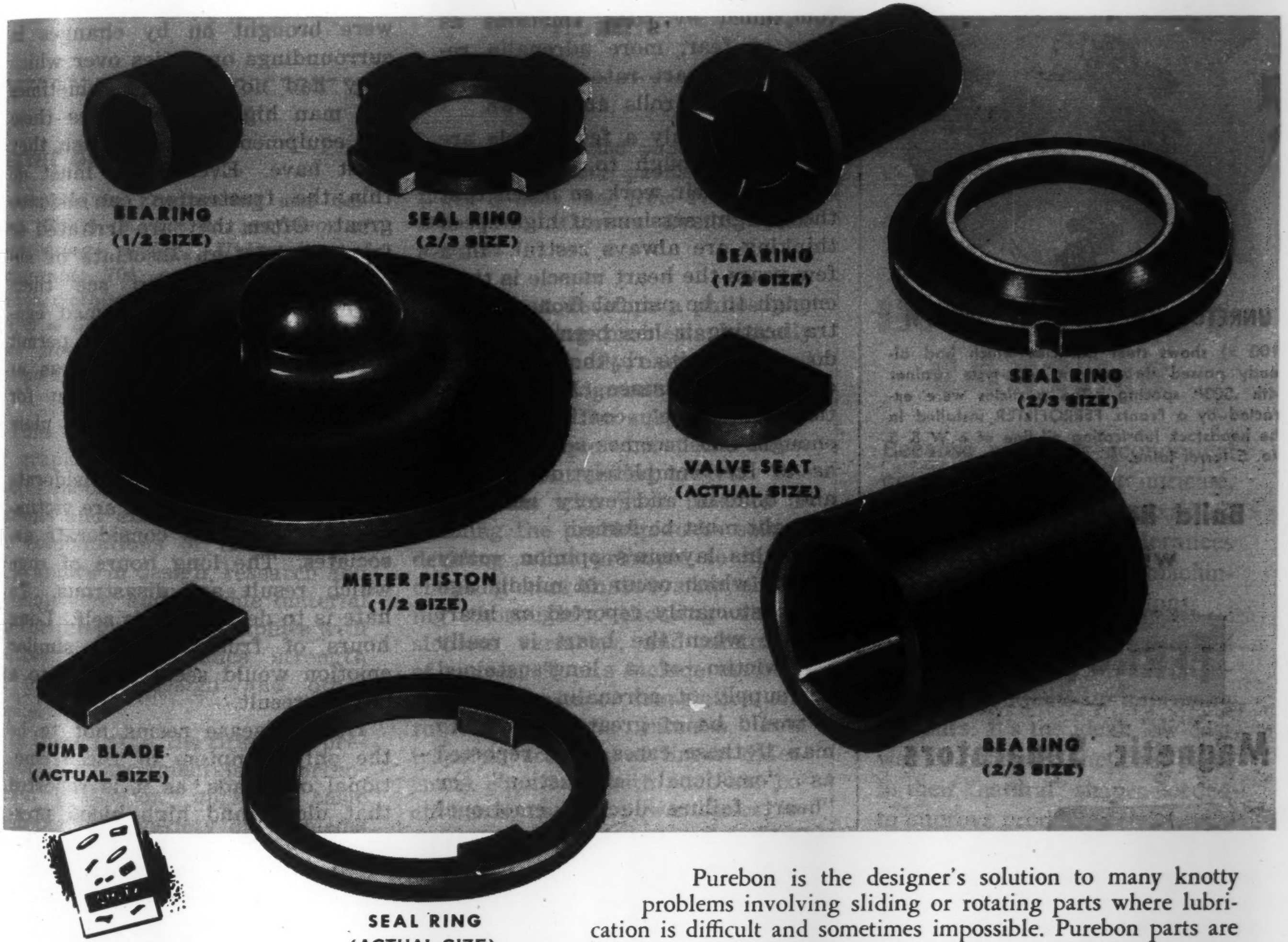
Since most "heart disease" occurs among those who are capable of creative thinking, its incidence must be affected by something connected with the thinking processes or the emotions. It also seems to be a condition which requires much time for its development.

There is reason to believe that many of these creative thinkers are victims of such tension-producing emotions as anxiety, apprehension, fear, rage, hatred, impatience, frustration, or specifically, any emotion which will stimulate the flow of adrenalin. If this continues over long-sustained periods it seems to be impossible for one to relax and the victim does not get sufficient rest.

The author believes a person can make more adrenalin in a work day of impatience or rage than one with a sedentary occupation can normally consume within the work time and, unless the larger muscles are brought to play daily to consume this adrenalin, it may still be in oversupply through the night. Perhaps the consumption of an oversupply of adrenalin is the principal benefit the sedentary worker gets from off-duty ex-

. . . the *solution* to your Lubrication problem is here . . . PUREBON

Carbon-graphite especially designed for mechanical applications.


BEARING (1/2 SIZE)
SEAL RING (2/3 SIZE)
BEARING (1/2 SIZE)
SEAL RING (2/3 SIZE)
METER PISTON (1/2 SIZE)
VALVE SEAT (ACTUAL SIZE)
PUMP BLADE (ACTUAL SIZE)
BEARING (2/3 SIZE)
SEAL RING (ACTUAL SIZE)

For complete information about PUREBON. Write for Bulletin 52

COMPRESSOR BLADE (2/3 SIZE)

Purebon is the designer's solution to many knotty problems involving sliding or rotating parts where lubrication is difficult and sometimes impossible. Purebon parts are molded or machined exactly to our customers' specifications here in our own plant, under our close supervision and inspection. *Because of the diversified characteristics of Purebon, applications are limited only by the designer's imagination.* If you have a problem involving insufficient lubrication at critical points of friction, our design engineering department will be happy to work with you toward its swift and successful solution.

PUREBON'S PROPERTIES

1. ***MOLDED TO SIZE—FOR MANY APPLICATIONS***
   Tolerances of approximately 1½% of dimension required for molding most shapes.
2. ***SELF-LUBRICATING—OR BY THE MATERIAL HANDLED***
   Varies with grade of Purebon.
3. ***STRONG AND TOUGH***
   Transverse strength varies from 4,000 to 13,000 lb./sq. in. according to grade.
4. ***READILY MACHINABLE***
   Tolerances as close as .0005 can be maintained where required.
5. ***CHEMICALLY INERT—NON-TOXIC***
   Resistant to attack by chemicals of all kinds, used in food handling and processing equipment.
6. ***HIGH TEMPERATURE APPLICATION***
   Most Purebon grades will operate efficiently in temperatures up to 700°F in air or much higher in neutral or reducing atmosphere.

Leaders for over 40 YEARS in PURE CARBON PRODUCTS

PUREBON

PURE CARBON CO., INC.
450 HALL AVENUE
ST. MARYS, PENNSYLVANIA

These Teeth Bite

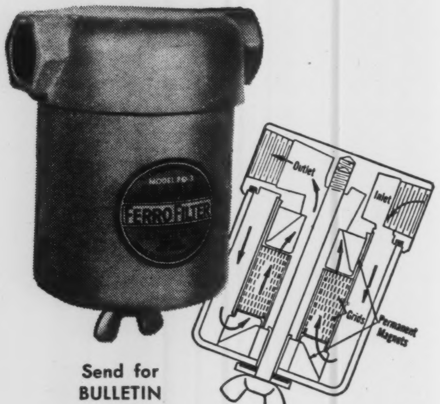
UNRETOUCHED PHOTOMICROGRAPH

(100 x) shows steel particles which had already passed through an edge-type strainer with .003" spacing. The particles were extracted by a Frantz FERROFILTER installed in the headstock lubricating oil line of a W & S No. 5 turret lathe.

Build Better Machines with FRANTZ

FERROFILTER®

Magnetic Separators



Send for
BULLETIN
PM-83

You can assure customers of lower maintenance and less expense for replacement parts on the machines you build. Frantz FERROFILTERS prevent damage to bearings, gears, pumps and other wearing surfaces caused by metal worn off moving parts and circulated through lubrication systems. These permanent magnet separators are compact, ruggedly built and easily cleaned. Nothing to wear out, no replacements to buy.

S. G. FRANTZ CO., Inc.

P. O. Box 1138 Trenton 6, N. J.

ercise. This oversupply can stimulate one to wakefulness, and unless he diverts his mind by reading or working on some hobby, his mind is soon racing along at a great rate. If this thinking is accompanied by such emotions as rage or fear, more adrenalin results, the heart rate is high and the snowball rolls and grows.

Probably only a few people are fortunate enough to enjoy every detail of their work so much that these night sessions of high-speed thinking are always zestful. In a few years the heart muscle is tired enough to be painful from the extra beating it has been forced to do, or loses its rhythm, and it is called heart disease. If this emotional fatigue continues long enough, one becomes so exhausted as to feel completely despondent and done-in and every move or thought must be forced.

In this layman's opinion, many deaths which occur in middle age are customarily reported as heart failure when the heart is really the victim of a long-sustained oversupply of adrenalin. Perhaps it would be of greater service to man if these cases were reported as "emotional exhaustion" or "heart failure due to emotional stress" or some such name.

These victims of "heart disease" may be divided into two classes: (1) those who bring it upon themselves, and (2) those who are the victims of circumstances or of one or more associates. There is doubt that either the associate or the victim often knows what has caused the trouble.

In the first class are many leaders who are extremely active, both during and after normal working hours. They are possessed by a compelling urge to "get it done" and often have not learned to relax, or refuse to do so.

If they do realize the effect of sustained high emotional tension without periods of relaxation, and choose to ignore it, that may be presumed to be their own business so long as they do not use their mode of life as the criterion of conduct for others. There are men in this class from the high-level executive down through the various levels of supervision to the high-strung individual worker.

The victims of circumstance are not so often found in the higher echelons of their respective organizations. Sometimes they are the victims of frustration in their efforts to surmount difficulties which could not be foreseen or which were brought on by changes in surroundings or duties over which they had no control. Sometimes the man higher up refuses them the equipment or men which they must have. Even if he must do this the frustration can be too great. Often they are irritated or frustrated by an associate or superior who likes to see them squirm, who is a confirmed egocentric, who is unwilling to permit them to use their own ideas or grant them any recognition for their efforts, or who is just plain short-sighted.

They are often very considerate of their fellow man and are victimized by their less considerate associates. The long hours of rage which result are disastrous. To hate is to destroy one's self. Long hours of frustration or similar emotion would seem to lead to a similar result.

Heart disease seems not to be the only symptom of these emotional overloads, as it is reported that ulcers and high blood pressure, among others, are in this category. Some time ago the author read about a man of near forty who quit a highly controversial position and soon found his blood pressure had dropped from 200 to 160 and was on the way down. Some will say that he couldn't take it, but that is an old-fashioned, superficial statement and begs the question.

The creative worker must be happy in his work to bring it the zest and exuberance necessary for full success and an interest in the subordinate's hour-by-hour happiness (not amusement) must be recognized as one of the prime duties of the supervisor. Everyone should learn about the destructive effects of the tension-producing emotions, and that when he or the man at the next desk becomes unhappy, damage is to be expected. He should learn this many years before the day of calamity can arrive.

THE ENGINEER'S Library

Recent Books

Graphics in Engineering and Science. *By A. S. Levens, professor of engineering design, University of California; 704 pages, 6½ by 9½ inches, clothbound; published by John Wiley & Sons Inc., New York; available from* MACHINE DESIGN, *$7.00 postpaid.*

This volume emphasizes the use of graphics as an important and useful mode of expression. Explanations and examples show effective combinations of the elements of graphics in design, research and development, and provide material for the integration of graphics with mathematics, mechanics, strength of materials, design and other topics.

In three parts, the first part presents the fundamentals of orthogonal projection, applying basic concepts to a variety of problems with emphasis on the analysis necessary for their solution. Part 2 deals with recognized standards of graphical representation, giving attention to improving technique and emphasizing development of facility in freehand sketching and simplification of drawings. Part 3 is concerned with graphical solutions and computations, showing the power of graphical methods, including graphical calculus in the solution of a variety of problems. Tables and material on such items as lettering and geometrical construction appear in the appendixes. Appropriate problems and examples are utilized throughout the book.

◆

Engineering Analysis — An Introduction to Professional Method. *By D. W. Ver Planck, head, department of mechanical engineering, and B. R. Teare, Jr., dean, college of engineering and science, Carnegie Institute of Technology; 356 pages, 5¾ by 9 inches, clothbound; published by John Wiley & Sons Inc., New York; available from* MACHINE DESIGN, *$6.00 postpaid.*

This book develops a philosophy of approaching problems logically and systematically, exercising good engineering judgment at each step of the work. The subject is developed by example with special stress on the whole thinking process. The book deals with such matters as defining the problem to be solved, deciding what principle to apply, choosing co-ordinate system, checking thoroughly, choosing dimensionless variables, and sketching of curves. Topics include material from dynamics of translation and rotation, electric circuits, heat transfer, solution of linear differential equations with constant coefficients, uses of power series, integration by graphical and numerical methods, hyperbolic functions and evaluation of indeterminate forms.

◆

Active Networks. *By Vincent C. Rideout, associate professor of electrical engineering, University of Wisconsin; 501 pages, 5⅛ by 8½ inches, clothbound; published by Prentice-Hall Inc., New York; available from* MACHINE DESIGN, **$10.65** *postpaid.*

Covering the fundamentals of all networks capable of amplification, this book gives a thorough treatment of the development of communication circuits. While primary emphasis is on vacuum tube circuits as applied to communications and control engineering, the transistor as well is discussed in considerable detail. There are also complete sections on thyratrons, magnetic amplifiers and position-control servomechanisms. Basic

FOR LOW-COST SMALL PARTS REPRODUCTION *choose...*

INVESTMENT CASTING

Because with this economical process you can cast intricate, undercut parts to meet exacting requirements as to tolerances and finish without costly machining and assembly operations.

Keep the investment casting technique in mind when designing new products or improving old ones. It's the ideal, low-cost way to produce functional parts in their "natural" shapes needed to improve product performance and appearance.

We'll be glad to assist you in planning your own investment casting department or to recommend casting firms equipped to serve your needs. This service will not obligate you in any way.

SEND FOR THE INVESTMENT CASTING STORY

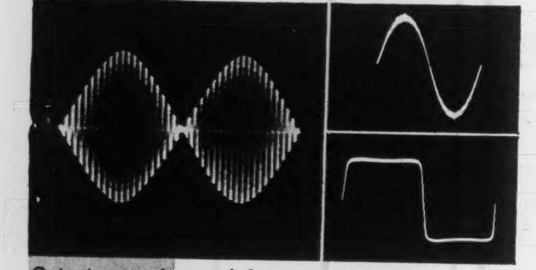
This free 12-page booklet — "MODERN PRECISION INVESTMENT CASTING"— contains informative data on how and where the process can be used.

[illegible]
Precision Casting Equipment
& Supplies
[illegible]

The New Servoscope®
puts another engineer
on your staff

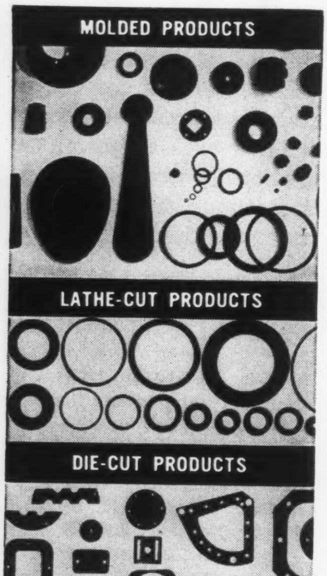
... but not
on your payroll

Are you engineering any type of feedback control system—regulators, governors, process controls, positioning or speed servos? With a Servoscope an extra engineer will be working for you on design synthesis, analysis or production test. • Breadboard your intended servo system or other circuit designs—then, by either the frequency response or the transient response method, magnitude and phase curves can be obtained directly within minutes. • For detailed information on how this versatile test instrument can save manpower, materials and money, write Dept. MD-9.


Output wave forms of Servoscope displayed against internal linear sweep generator, frequency ½ cps.

SERVO CORPORATION OF AMERICA
New Hyde Park, New York
SC122A

HERE'S WHAT
Goshen Rubber Can do
FOR YOU



Developing and producing *specialized* rubber parts, compression-molded O-rings and stock mold items . . . to meet customer's exact requirements . . . from natural, synthetic and silicone compounds, is our business. Your inquiry regarding *any* rubber parts problem, especially in the design stage, is invited.

New 4-page brochure and handy file folder tells what Goshen Rubber can do for you. Send for your free copy today!

Goshen Rubber Co. INC. Goshen, Indiana
1794 S. Tenth St.

ideas regarding band width, signal-to-noise ratio and information capacity of a system are introduced to clarify the design of active networks. Appendixes include mathematical details and tube and transistor curves.

◆

Metals and How to Weld Them. *By T. B. Jefferson, editor,* The Welding Engineer, *and Gorham Woods, metallurgist;* **335** *pages,* **5½** *by* **8½** *inches, clothbound; published by and available from the James F. Lincoln Arc Welding Foundation, Cleveland* **17,** *Ohio,* **$2.00** *per copy in U. S. A.,* **$2.50** *elsewhere.*

This combination text and reference book is intended to give all users of welding a practical working knowledge and source of information for designing and making better welds at lower cost. The first six chapters are devoted to elementary discussion of metals, their mechanical and physical properties and uses. Next, fundamentals of metallurgy and their significance in heat treating and welding are explained in logical steps. This information is then related to correct welding procedures for steels, cast iron, nonferrous materials and hardfacing. The final section of the book is devoted to information for making good welds, trouble shooting, cost estimating and explanation of terms.

◆

Lubrication of Industrial and Marine Machinery. *By the late William Gordon Forbes; revised by C. L. Pope and W. T. Everitt;* **359** *pages,* **5¾** *by* **9** *inches, clothbound; published by John Wiley & Sons Inc., New York; available from* **MACHINE DESIGN, $6.50** *postpaid.*

With the purpose of explaining fundamental characteristics of conventional lubricants, this second edition integrates lubrication principles with lubrication requirements.

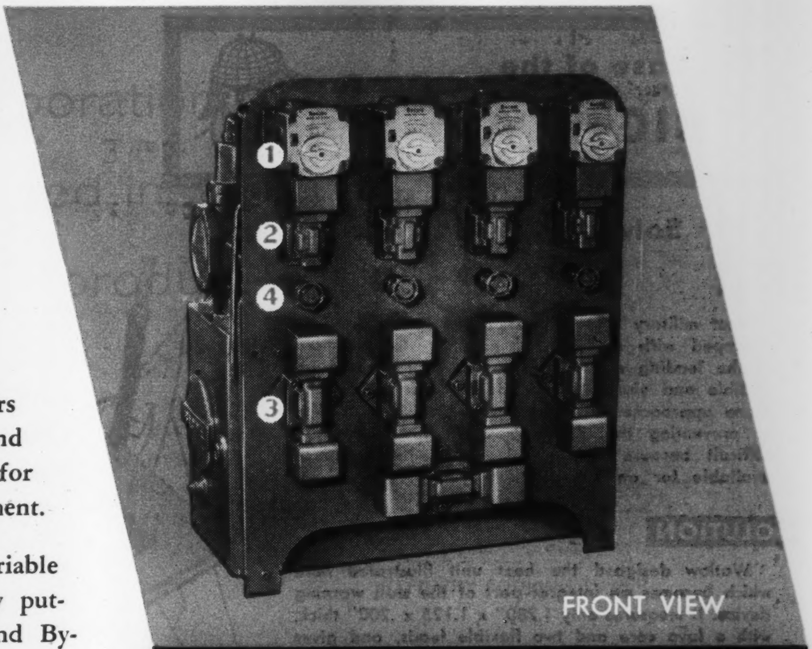
The first 14 chapters deal with the chemistry, refining, compounding and specifications for lubricants. Chapters 15 through 32 explain the lubrication requirements

RACINE

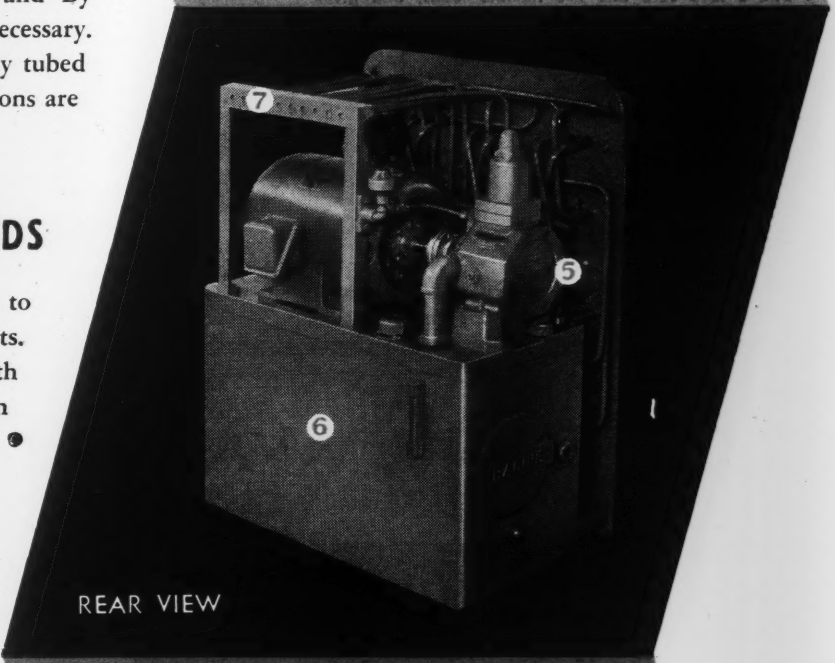
HYDRAULIC POWER PLANTS

A RACINE packaged Power Unit offers you maximum flexibility in operation and performance. It comes complete, ready for immediate installation on your equipment.

The heart of this system, a RACINE Variable Volume Pump, conserves horsepower by putting all of the oil to work. Relief and By-pass Valves with extra piping are unnecessary. On this unit all control valves are neatly tubed to a terminal block from which connections are made to the machine.



FRONT VIEW



REAR VIEW

DESIGNED FOR YOUR NEEDS

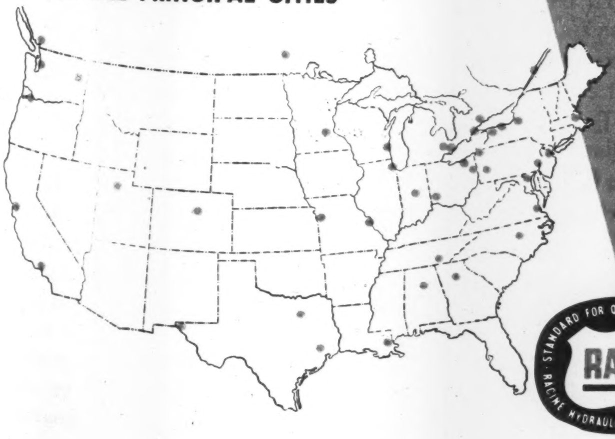
These package units can be designed to meet your space and circuit requirements. All components are centrally located with the Control Valves positioned on an easily accessible control panel. Investigate the possibilities as applied to your products. Write for complete RACINE Hydraulic Catalog and the name of your nearest RACINE Field Office offering a complete engineering service.

KEY TO PARTS

- ① RACINE FEED VALVE
- ② RACINE DIRECT SOLENOID OPERATED 2-WAY VALVE
- ③ RACINE DIRECT SOLENOID OPERATED 4-WAY VALVE
- ④ GLOBE SHUT-OFF VALVE
- ⑤ RACINE VARIABLE VOLUME PUMP
- ⑥ RACINE OIL RESERVOIR
- ⑦ TERMINAL BLOCK

"They Work Better Together"

SALES AND SERVICE REPRESENTATIVES IN ALL PRINCIPAL CITIES



STANDARD FOR QUALITY AND PRECISION
RACINE
RACINE HYDRAULICS & MACHINERY INC.

RACINE HYDRAULICS
& MACHINERY, INC.
2073 Albert Street, Racine, Wisc., U. S. A.

The Case of the
"BIG STALL"

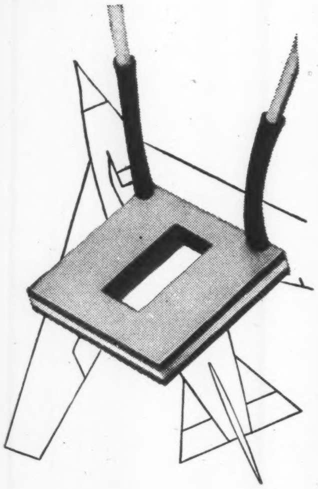
Solved by WATLOW ELECTRIC HEAT

CASE

Most military and commercial aircraft today are equipped with a "stall warning" device mounted in the leading edge of the wing, which gives an audible and visual warning to the pilot when the plane approaches a stalling attitude. The problem of preventing this device from freezing was very difficult because of the limited amount of space available for an electric heating unit.

SOLUTION

Watlow designed the heat unit illustrated here which becomes an integral part of the stall warning device. It measures only 1.280" x 1.125 x .200" thick, with a lava core and two flexible leads, and gives sufficient heat to prevent freezing of the stall warning device. This is only one of many types of heating units which Watlow has designed for military and commercial aircraft.



WATLOW

HOT PLATES IMMERSION BAND CARTRIDGE

Since 1922—Designers and Manufacturers of Electric Heating Units

ELECTRIC MFG. CO.
1384 FERGUSON AVE.
SAINT LOUIS 14, MO.

WATLOW solves unusual electric heating problems every day. What is your heating problem?

COPIES STILL AVAILABLE

MACHINE DESIGN

"DIRECTORY OF MATERIALS"

18th Edition $1⁰⁰ Per Copy

of the most common types of machinery, including bearings, methods for applying lubricants, oil purification and reclaiming, machine storage and shipment, engines, turbines, hydraulic systems, fluid couplings, air compressors, vacuum pumps, pneumatic tools, refrigerating machines, gears, heat treating oils and cutting oils. The last two chapters give practical examples of applying the foregoing to the lubrication of equipment.

Association Publications

Standards in a Changing World—Proceedings of the Fourth National Standardization Conference and the Thirty-Fifth Annual Meeting of the American Standards Association. 76 *pages,* 8½ *by* 11 *inches, paperbound; available from the American Standards Association,* 70 *East 45th St., New York* 17, *N. Y.,* $3.00 *per copy.*

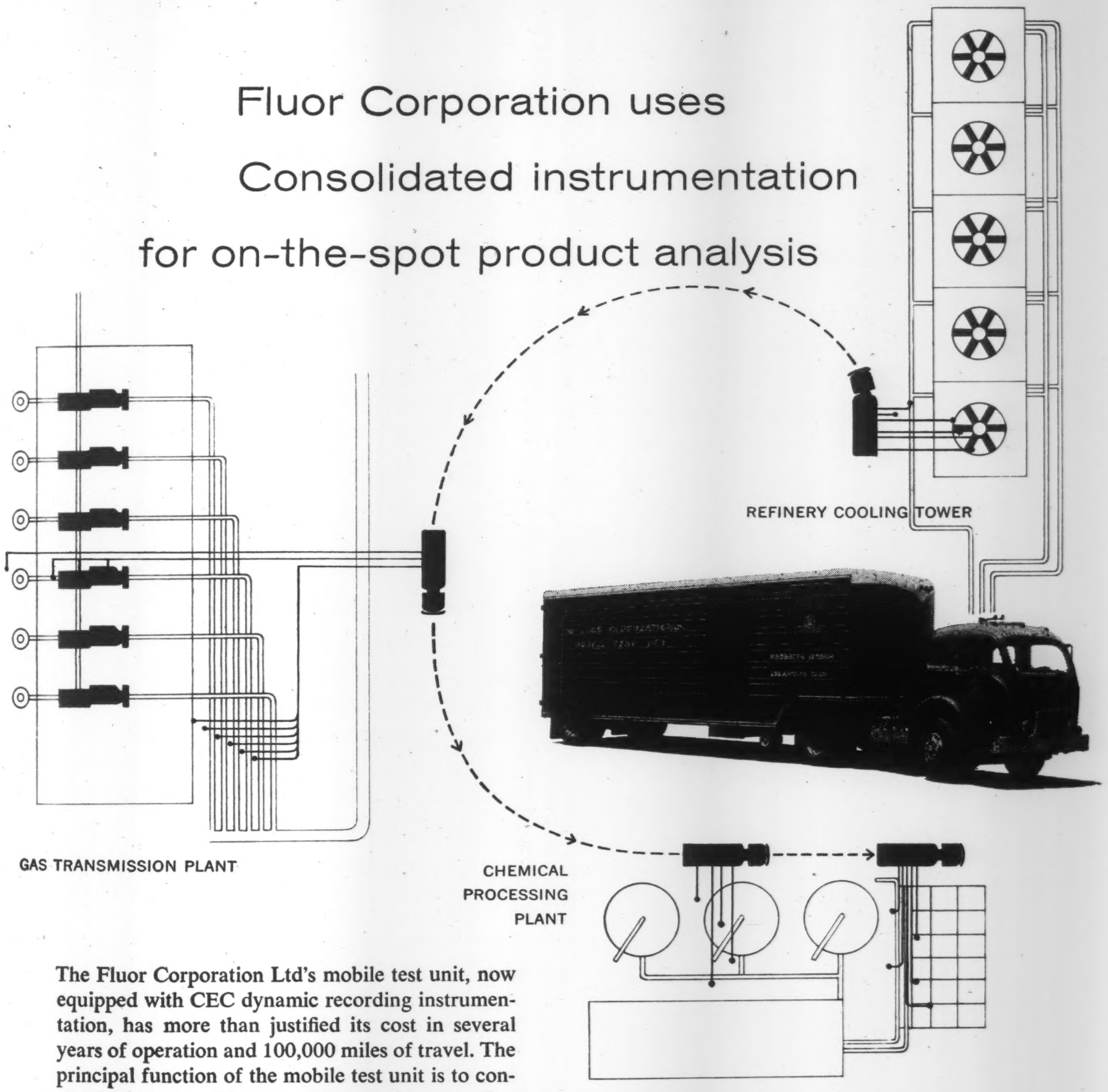
This booklet contains the papers presented at the Standardization Conference and the addresses made at the Thirty-Fifth Annual Meeting and Awards Luncheon of the American Standards Association. Other sections include panel sessions on purchasing, quality control and factors involved in organizing company standards; a symposium on industrial noise; and a report by the National Bureau of Standards on design and production of electronics.

◆

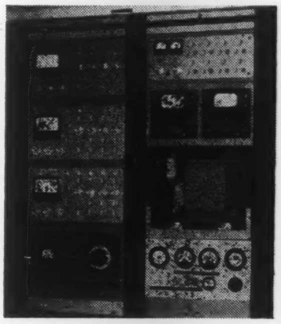
Constructional Alloy Steels. Chemical Composition Limits, H-Steels Hardenability Limits—Supplement to Sections 10, 18, 28 and 29, Steel Products Manual. 60 ***pages,*** **8½** ***by*** **11** ***inches, paperbound; available from American Iron and Steel Institute, 350 Fifth Ave., New York 1, N. Y., on company letterhead request.***

Lists of steel compositions in this bulletin supersede all others of earlier dates contained in Sections 10, 18, 28 and 29 of the Steel Products Manual. The ranges and limits in these lists apply to steel not exceeding 200 square inches in cross sectional area, or 18 inches in width, or 10,000 pounds weight per piece.

Fluor Corporation uses Consolidated instrumentation for on-the-spot product analysis



The Fluor Corporation Ltd's mobile test unit, now equipped with CEC dynamic recording instrumentation, has more than justified its cost in several years of operation and 100,000 miles of travel. The principal function of the mobile test unit is to constantly improve Fluor products such as cooling towers, pulsation dampeners and fin fan air-cooled heat exchangers by on-the-spot dynamic testing under actual operating conditions. Using a 14-channel Consolidated Recording Oscillograph, Carrier Amplifiers, Transducers and associated CEC equipment, the mobile unit can measure and permanently record every physical phenomenon encountered in the operation of Fluor's products for the petroleum and petro-chemical industries. The attractive mobile unit in its specially built van trailer serves other purposes aiding the solution of field engineering problems and conducting basic research.



Consolidated dynamic recording equipment: recording oscillograph, vibration meters, bridge balance and carrier amplifiers, are rack-and-panel mounted in Fluor's mobile research laboratory.

Free Catalog. *Write for illustrated brochure "Data Processing Instruments." Ask for Bulletin 1301-X1.*

Consolidated Engineering
CORPORATION
300 North Sierra Madre Villa, Pasadena 15, California

Sales and Service through **CEC INSTRUMENTS, INC.,** *a subsidiary with offices in: Pasadena, Atlanta, Chicago, Dallas, Detroit, New York, Philadelphia, Washington, D. C.*

ANALYTICAL
INSTRUMENTS
FOR SCIENCE
AND INDUSTRY

WORLD'S LARGEST PRODUCER OF MOLDED

Triple "M" is the Electric Motor Maker's No. 1 Source for Precision Engineered

COMMUTATORS

BRUSH CAPS • BRUSH HOLDERS

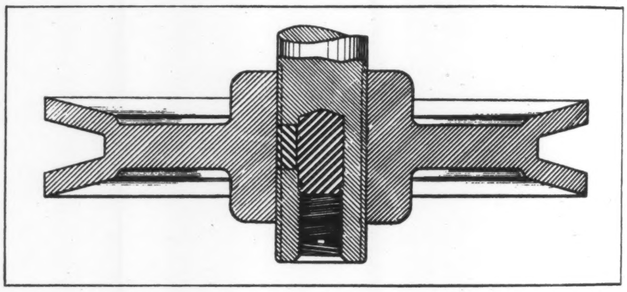
Midwest Molding
AND MANUFACTURING COMPANY
4630 W. Fullerton Avenue
Chicago 39, Illinois

TRIPLE "M" ELECTRONENTS

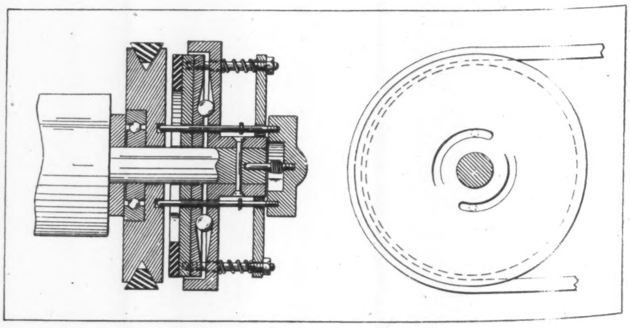
MANY STOCK SIZES ... WRITE FOR CATALOG

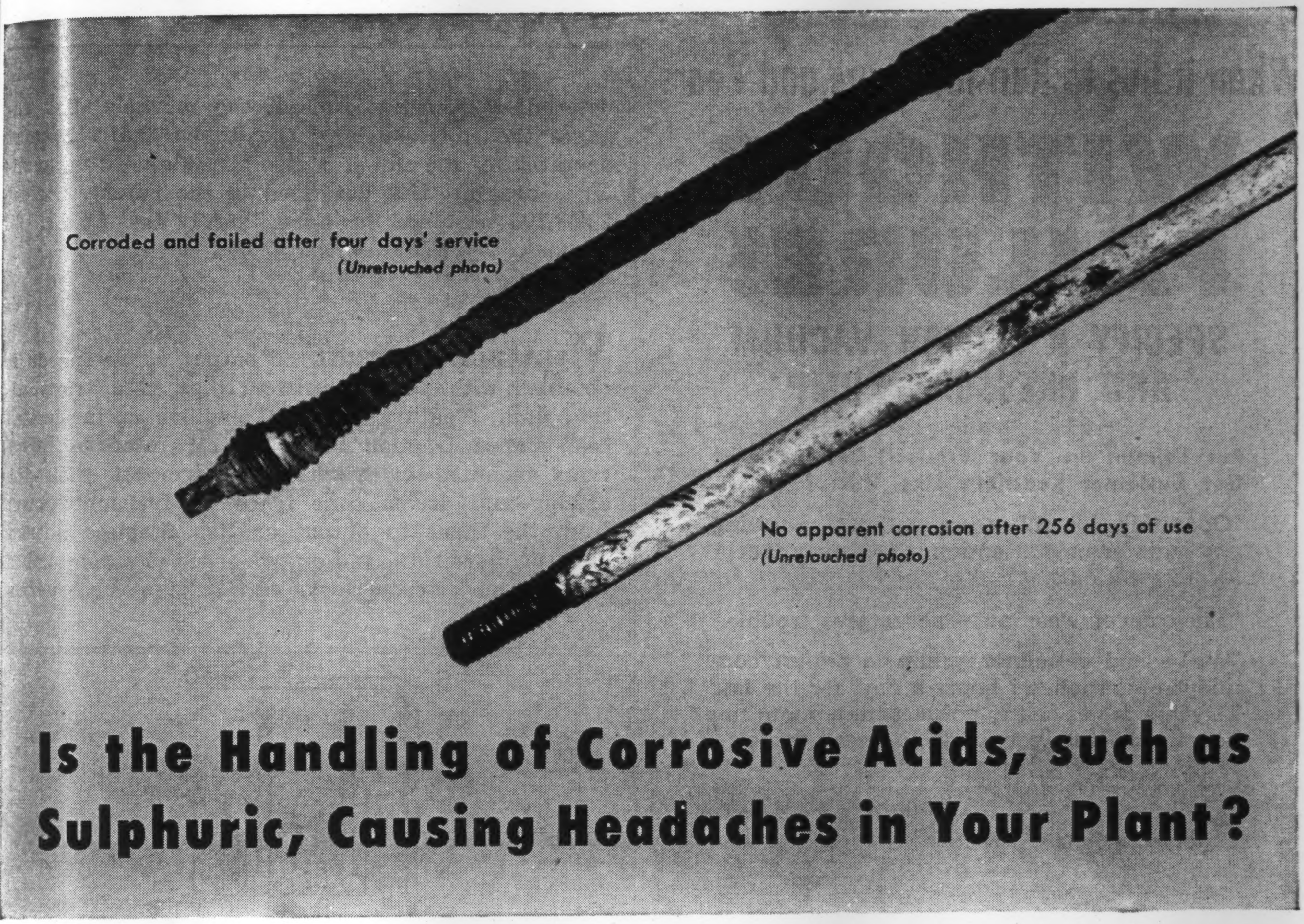
NOTEWORTHY Patents

RUBBER KEYS simplify assembly and disassembly of splined connections and prevent relative axial movements under load. Secure locking of splined hub and shaft assemblies is obtained with a rubber plug mounted in a tapped hole in the end of the shaft. Pressure applied to the end of the plug by means of a set screw forces the rubber to extrude through a radial hole in the shaft, frictionally engaging the hub bore and preventing axial movement. Overtightening during assembly is prevented by the resilience of the rubber which also acts to lock the set screw adjustment. It can be assembled and disassembled many times without danger of damage. *Patent 2,651,531 assigned to Maytag Co. by T. R. Smith.*



AUTOMATIC CONTROL of clutch engagement in response to input speed is achieved with a centrifugal friction clutch design. Clutching action is provided by balls mounted between two disks which have mating tapered radial grooves; one disk is fixed to the shaft, the other is spring-loaded but free to move along the shaft. Centrifugally actuated, the balls move outward in the tapered grooves as shaft speed increases, tending to separate the disks. At a pre-

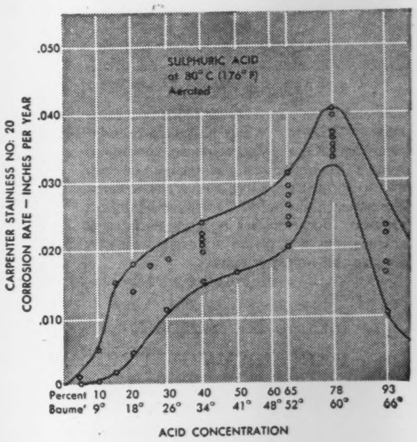



Corroded and failed after four days' service
(Unretouched photo)
No apparent corrosion after 256 days of use
(Unretouched photo)

Is the Handling of Corrosive Acids, such as Sulphuric, Causing Headaches in Your Plant?

Today many plants are enjoying new freedom from corrosion, longer equipment life and fewer shutdowns . . . because of Carpenter Stainless No. 20. Take the job shown above. In this application, ½" rd. rods of Carpenter No. 20 and Stainless Type 316 were installed to handle H_2SO_4 at the rate of about 50 gallons a minute in a full range of solution varying from 0% up to 58% concentration. Temperature: 70° C. (158°F.). After four days the Type 316 rods failed and were replaced with ½" sq. No. 20 rods. After being in service 3,747 hours of a possible 6,144 hours over a period of 256 days, the No. 20 rods showed no apparent corrosion whatsoever. (See unretouched photo above.) Of course, Type 316 is satisfactory for certain dilute solutions of H_2SO_4 and many other corrosive conditions. But with a tough problem like the one described here, it takes No. 20 to do the job.

Note the band of corrosion resistance in the chart to the right. Consider it from the standpoint of how Stainless No. 20 can help you cure your own headaches in handling sulphuric acid. Of course, we'll be glad to work with you in any way we can. As a start, drop us a line on your company letterhead for Carpenter's booklet of more detailed information on No. 20. Test coupons are also available at your request. Investigate now how you can solve, once and for all, your costly corrosion problems. THE CARPENTER STEEL COMPANY, 120 W. Bern St., Reading, Pa.



Carpenter STEEL

Stainless No. 20

Contact The Carpenter Steel Company, Alloy Tube Division, Union, New Jersey, for Carpenter Stainless No. 20 in the forms of Tubing, Sheet and Plate.

Export Department: The Carpenter Steel Co., Port Washington, N.Y.—"CARSTEELCO"

Mill-Branch Warehouses and Distributors in Prin cipal Cities Throughout the U.S.A. and Canada

When it has to Run for Years and Years

WITHOUT FAILURE!

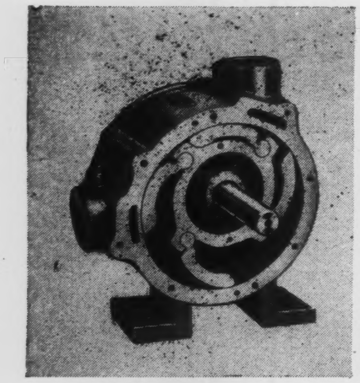
SPECIFY A LEIMAN VACUUM AND PRESSURE PUMP

Put Leiman in Your Product Designs And Get Customer Reactions Like This:

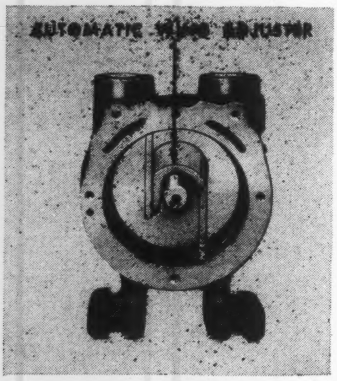
"Operating for 12 years without requiring any maintenance attention whatsoever except for lubrication."

"They never wear out—never give trouble."

"We've had a Leiman pump in almost continous operation, 24 hours a day, for the last 21 years. It's as nearly noiseless as a pump can be . . . absolutely reliable in every respect."



4-WING TYPE
Vacuums to 20"; pressures to 15 lbs.; displacement to 162 cfm. Wings hinged to piston—centrifugal force maintains close, continuous contact to cylinder wall. Wings take up their own wear, insure positive pressure or vacuum. No composition material to require frequent renewal. Air chamber is large because of small piston size, giving unmatched capacity for size and weight of pump.



2-WING TYPE
Vacuums to 29.9"; pressures to 25 lbs.; displacement to 40.8 cfm. Blades cannot stick, because of exclusive Leiman automatic wing adjusting lever which forces each blade to meet cylinder wall, insures positive pressure or vacuum. Only steel blades (no composition) are used. They take up their own wear, deliver years of trouble-free service.

Look to Leiman in designing products like vacuum packing and filling machines . . . paper feeding agitators . . . vacuum chucks . . . liquid transfer equipment . . . or any other device requiring continuous, non-pulsating flow of air for vacuum or pressure.

Write for catalog and special bulletin on 60 representative applications.

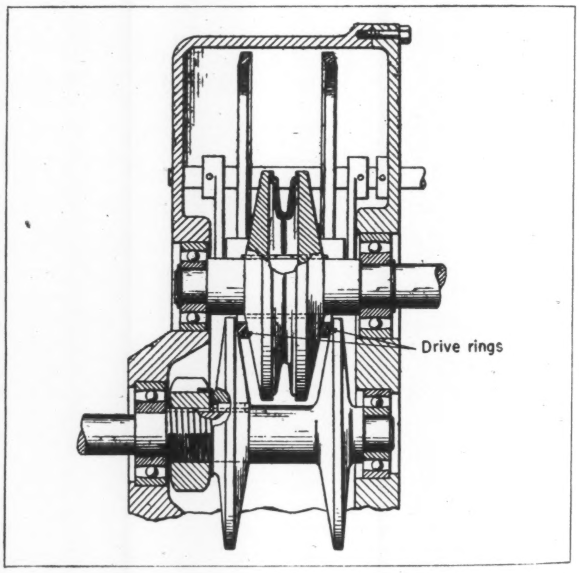
SEE OUR CATALOG IN SWEETS FILE

LEIMAN BROS., INC.

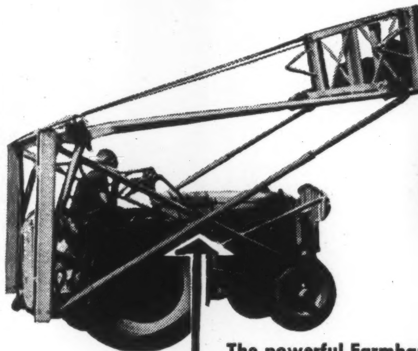
148 Christie Street
Newark 5, N. J.

determined rotational speed, the movable disk engages the clutch disk of the driven shaft. Manual operation of the clutch is also possible with an auxiliary engaging disk described in the patent. *Patent 2,663,396 assigned to Easy Power, Inc. by A. W. Wagner.*

VARIABLE CONTROL of output shaft speeds is obtained with power transfer rings in a transmission unit. The transmission employs spring-loaded cone-shaped traction members, separated by drive rings mounted in frictional engagement with the driving and driven cone faces, to transmit power from the input to output shafts. Stepless adjustment of drive ratio and output speed is accomplished through an external lever and linkage construction which controls the position of the rings along the cone faces. Drive ratio stability is maintained by preforming the drive rings in a conical shape to conform to the cone traction surfaces. Unbalanced thrust forces are prevented in the design by mounting the transmission members in pairs in an equalizing arrangement. A modification of the unit for bidirectional drive applications is also described. *Patent 2,659,245 assigned to W. C. Maxson Corp. by P. J. McLaren.*



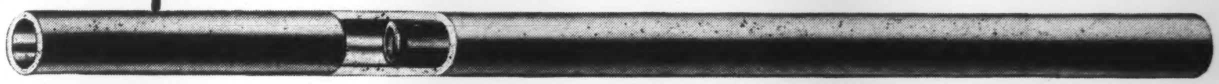
EMERGENCY CONTROL MECHANISM allows immediate changeover from a motor control to manual control without the necessity of clutches or changing gears. The device uses an internally threaded sleeve inside which a control shaft can be made to move along its axis by rotation of the sleeve. Since rotation of the shaft with the sleeve held stationary will also cause the shaft to move axially, a gear is fitted on the splined end of the shaft to provide a second



The powerful Farmhand Hi-Lift Loader designed for farm use is also used effectively for industrial loading and lifting. Attaches easily to most tractors.

Problem: To keep a hydraulic seal from being chewed up

Solution: Use Mirror-Finish ELECTRUNITE Hydraulic Cylinder Tubing



Result: Seals stay smooth

That hydraulic cylinder you're looking at is part of the Farmhand Hi-Lift Loader. It's 10 feet long. And it has to be mirror-smooth inside, or the rubber and fabric cups which seal the hydraulic fluid will be chewed up, sometimes, in a matter of hours.

Farmhand formerly made the part out of steel tubing manufactured by another process. Sometimes, interior scratches were detected before assembly. That meant an expensive honing operation or a high rejection ratio which hampered production. If they weren't caught, the rubber cups wore out in a hurry. The customer complained to the dealer. The dealer complained to Farmhand.

The company got together with the Republic salesman and the Republic metallurgist. They discussed the problem, finally came up with an answer: ELECTRUNITE Hydraulic Cylinder Tubing, 3″ x .134″ wall. And here's what they got.

1. Lower cost. Tubing can be used as it's received from Republic with no extra operations.
2. More consistently uniform inside surface finish.
3. Longer life on the cups that act as seals for the hydraulic fluid.
4. Harder surface in a higher Rockwell range than they had in tubing they formerly used.
5. A low ratio of rejections.

This is what we mean by precision tubing. And it's particularly economical in hydraulic applications. If you'd like to know where it fits into your production picture, just call your nearest Republic district office. And do it soon.

REPUBLIC STEEL CORPORATION
Steel and Tubes Division
217 E. 131st Street, Cleveland 8, Ohio
GENERAL OFFICES CLEVELAND 1, OHIO
Export Department: Chrysler Building, New York 17, N. Y.

REPUBLIC
ELECTRUNITE TUBING

Other Republic Products include Carbon and Alloy Steels — Titanium — Pipe, Sheets, Strip, Bars, Wire, Pig Iron, Bolts and Nuts, Tubing

HOLLOW LOCK SCREW • STRIPPER BOLT OR SHOULDER SCREW • FLAT HEAD SOCKET SCREW
SOCKET HEAD CAP SCREW • HOLLOW SET SCREW • HOLLOW PIPE PLUG • SOCKET SCREW KEY

WHEN YOU USE

Mac-it®

YOU GET

PEAK PERFORMANCE

STRENGTH WITHOUT BULK

Lower cost, smaller size Mac-it Screws can be used for all fastening jobs because of their exceptional tensile and torsional strength. Made from special Mac-it Alloy Steel held to rigid specifications, Mac-it Screws insure uniform and dependable screw performance.

SPECIAL SCREW PRODUCTS

Mac-it is geared for large or small run production of screws with special design or strength characteristics. The high quality of Mac-it special Alloy Steel adapts it to heat treatment that penetrates throughout the screw structure so that the center possesses the same sturdy toughness as the outside. Each type Mac-it Screw is heat-treated for maximum strength in its specific use.

PRECISION FASTENERS

The precision manufacture and quality control used in making Mac-it Screws provide users with high dimensional accuracy and uniformity. All Mac-it Screws in both coarse and fine threads are held to a class-3 fit. Mac-it maintains a fastener engineering service for the design, development and production of screws for all types of applications.

DISTRIBUTOR SERVICE

Contact any of the hundreds of Mac-it distributors from coast to coast for immediate service to supply your requirements for standard or special screw products.

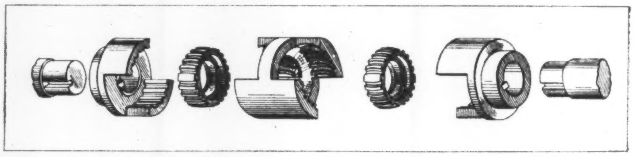
MAC-IT SCREW DEPARTMENT
STRONG, CARLISLE & HAMMOND COMPANY
1392 W. 3RD. STREET • CLEVELAND 13, OHIO
Manufactured by Mac-it Parts Co., Lancaster, Pa.

Contact your nearest Mac-it Distributor or the Home Office, Cleveland, Ohio, for full information on how Mac-it can solve your screw problems.

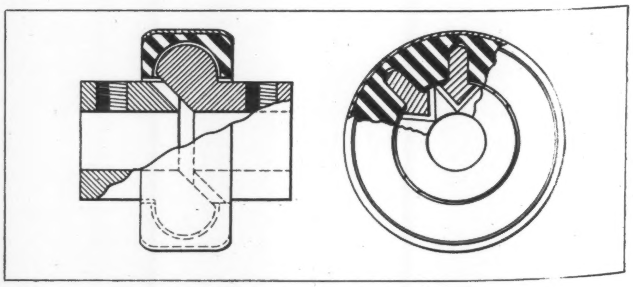
HEX HEAD CAP SCREW • ROUND HEAD SCREW • FLAT HEAD SCREW • MINING MACHINE SCREW
SLOTTED SET SCREW • SQUARE HEAD SET SCREW • TOOL POST SCREW • FILLISTER HEAD SCREW

means of moving the shaft. The sleeve may be turned by a motor with a worm gear drive. Manual control of the shaft may be by means of a handwheel and worm drive to rotate the gear sliding on the splined end of the shaft. Operation of either of these controls will not affect the other nor will there be back-drive to overcome. *Patent* 2,660,072 *assigned to Continental Foundry and Machine Co. by V. V. Veenschoten.*

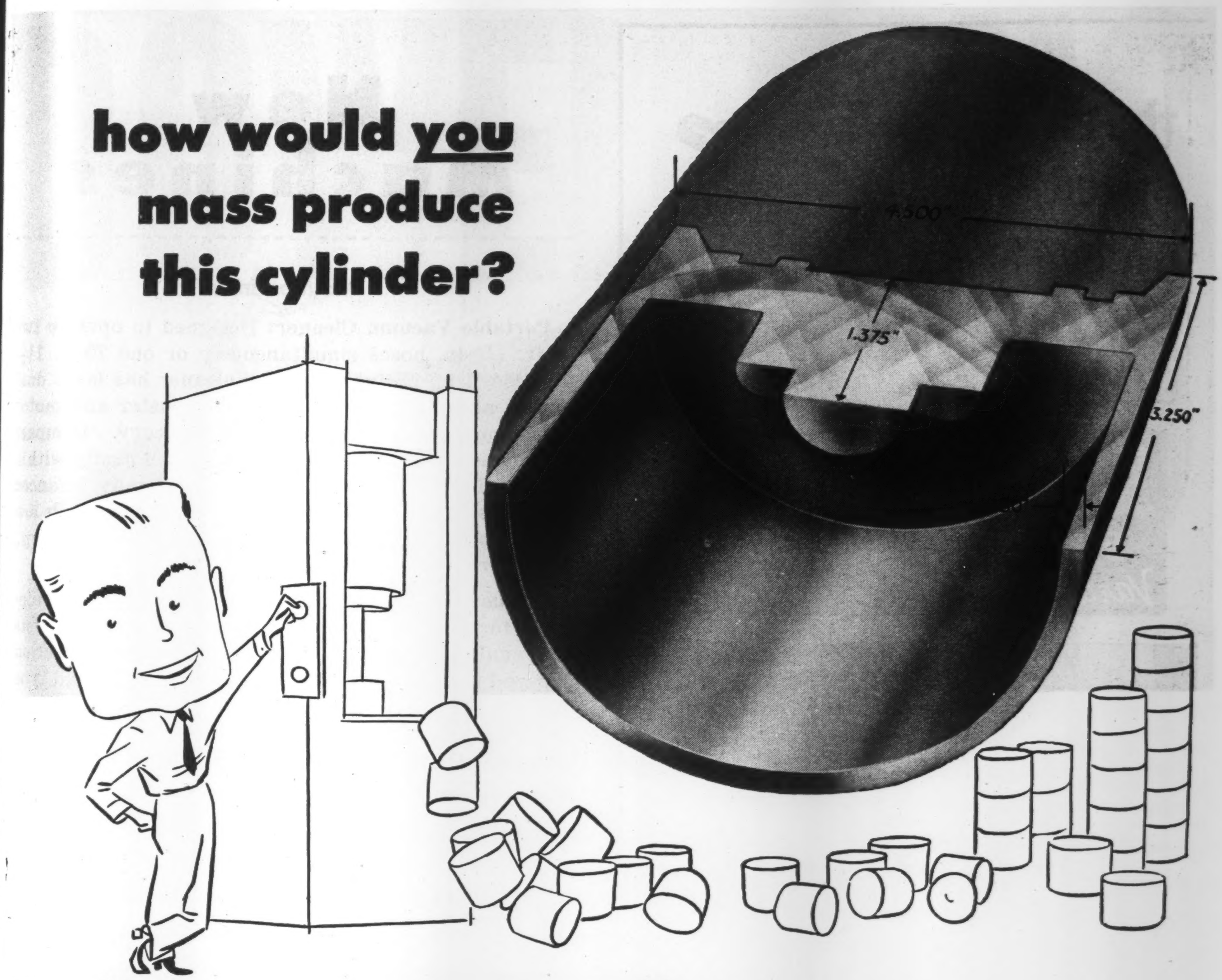
SPLINED BALL JOINTS in a universal shaft coupling minimize friction and wear and offer high torque capacity under severe misalignment conditions. Curved parallel splines on the surface of a ball-shaped driving member mate with internal rectangular splines on a driven tubular sleeve which fits over the ball. Because of the large contact area between the driving and driven splines of the coupling, heavy loads may be transmitted. A sliding and rocking action between the two members compensates for shaft misalignment during rotation. *Patent* 2,659,217 *assigned to United Engineering and Foundry Co. by H. H. Talbot.*



RUBBER COUPLING facilitates connection of misaligned rotating shafts. Identical rubber driving members are fitted on the end of each shaft. Each driving member has arms interlocking with the other and each is equipped with rubber driving lugs. An elastic rubber sleeve fitted around both interlocking members has openings to engage the rubber driving lugs of both members. Torque is transmitted by the driving lugs of the driving member, through the rubber sleeve to the lugs of the driven member. Relatively inexpensive, the invention is durable and efficient in operation. *Patent* 2,655,798 *assigned to General Tire and Rubber Co. by E. P. Neher.*



how would you mass produce this cylinder?



For efficiency and economy specify . . .

H|D IMPACT FORGING

FROM

HIGH STRENGTH ALUMINUM ALLOYS

Strength requirements of this cylinder were satisfied by using a heat treatable aluminum alloy (minimum yield 55,000 P.S.I.). By the Hunter Douglas cold Impact Forging technique, this high strength aluminum alloy was forged in a single operation to the desired shape . . . mass production at its finest . . . with close dimensional tolerances, forged grain flow and walls of zero draft.

The raised stud in the center of the piston offered an added design problem that, by any other process, would present a tremendous time consuming contour milling operation, in addition to high metal waste. The economic advantages of producing this part with minimum metal waste and in a single forging operation are immediately evident. When you are designing a part with the following characteristics:

Walls of zero draft...High physical properties ...Tubular shapes with or without a closed end ...Close dimensional tolerances...Mass production requirements up to a million a month...

IMPROVE YOUR COMPETITIVE POSITION . . .
SPECIFY HUNTER DOUGLAS

We invite you to submit blue prints or parts for our engineering department's prompt analysis.

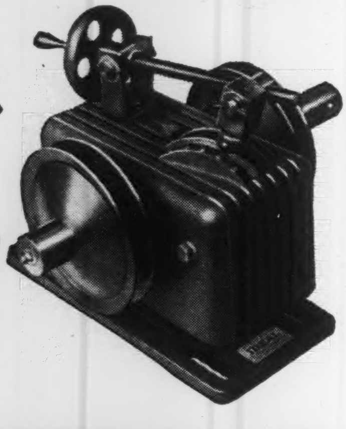
IMPACT FORGING • TOLERANCE OF EXTRUSION • STRENGTH OF FORGING
H|D

write for free literature on your company letterhead

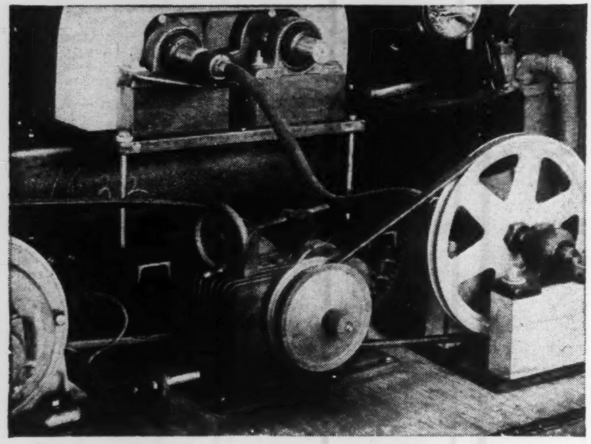
HUNTER DOUGLAS CORPORATION

DEPT. MD-9 • RIVERSIDE, CALIFORNIA • TELEPHONE RIVERSIDE 7091

the right speed always to FIT THE JOB!



LOVEJOY
SELECT-O-SPEED
Variable Speed Transmissions



A Select-O-Speed Transmission is used here to drive and control the speed of a pulley and flexible shaft connected to a vibrator that checks vibration of vehicular components at changing speeds.

Lovejoy's accurate, easily installed Select-O-Speed Transmission gives you complete and instant speed control on all types of machinery—new or old. Even while the machine is running you can adjust to an almost infinite number of speed variations.

Adjustments for testing . . . operator ability . . . variously sized parts or stock . . . material differences . . . any other operational variables . . . can be accomplished without loss of time or labor.

Lovejoy Select-O-Speed Transmissions provide better, more efficient production control to help you improve the quality of your products.

Speed ratios to 10 to 1. Sizes to 5 hp. Hand lever or wheel control. Operate with standard V-Belt drives. Fully enclosed. Send now for illustrated catalog giving complete information.

LOVEJOY FLEXIBLE COUPLING CO.
4818 W. Lake Street Chicago 44, Ill.
Mfrs. of flexible couplings, universal joints, variable speed pulleys and variable speed transmissions.

New Machines

Maintenance

Portable Vacuum Cleaner: Designed to operate two 50-ft, 1½-in. hoses simultaneously or one 75-ft, 1½-in. hose, 5 hp portable vacuum cleaner has large dust bucket and is equipped with an exhauster and motor which produce suction of 6.5 in. mercury. Compact and maneuverable, Hoffco-Vac 35 turns easily within its own length. Dynamically and statically balanced impellers in the exhauster permit operation with low vibration and noise. *U. S. Hoffman Machinery Corp., New York, N. Y.*

Furnace, Flue and Chimney Cleaner: Vacuum equipment for furnace, flue and chimney cleaning consists of a tank assembly on rollers, a large dust collection bag and bag support. Medium duty 2/3-hp hand type cleaner serves as power source. Tank, which collects heavy dirt and other objects, has 12-gal capacity. Bag has large surface area which allows low-velocity air to exhaust through the pores of the cloth while filtering out all soot, fly-ash and other dirt. Hoses are tough rubber or flexible metal, and nozzles have scrapers and wire or bristle brushes to loosen as well as collect dirt, ashes and soot. *Ideal Industries Inc., Sycamore, Ill.*

Materials Handling

Fork Lift Trucks: G-52 series of small, maneuverable gasoline-powered trucks are made with capacities of 2000, 3000 and 4000 lb. Truck has flywheel with integral single-circuit fluid coupling which reduces overhang and overall length; muffler designed to provide cool running; and hypoid gear drive with four-pinion differential. Pneumatic or solid tires are available. *Yale & Towne Mfg. Co., Philadelphia, Pa.*

Electric Hoists: Overhead materials-handling hoists have capacities ranging from 4 to over 15 tons. Standard models of 4, 5 and 6-ton capacities have wire rope lift with swivel hook suspended on a two-part line. Suspension is by lug, hook or plain or geared trolley. Positive load control down to increments of a fraction of an inch is possible. Hoist motors operate from a power source of 220 or 440-v, three-phase ac, and are controlled from a two-button control box suspended directly beneath the hoist. *R. G. LeTourneau Inc., Longview, Tex.*

Platform Truck: Low-lift electric platform truck with 6000-lb capacity lifts skids of various heights. Platform lift is 10 in., with low position of 7 in. Standard platform is 20 x 72 in.; other sizes can be specified. Tandem wheels are articulated for travel over rough or uneven floors. Truck is operated by Rolotac snap-acting control. Rolling snap action is engineered for instantaneous make and break of all

DOWEL PINS

HOW TO USE THEM

1. Precision Dowel Pins are principally used where parts must be accurately positioned and held in absolute relation to one another whether stationary or in motion. They facilitate quick disassembly and completely accurate re-assembly.
2. Allen Dowel Pins are also used as plug gauges.
3. As plugs for determining angular dimensions of dovetail slides.
4. As hinge and wrist pins in applications requiring initial and permanent accuracy.
5. As accurate, economical roller bearings and axles.
6. As guide pins, stops and position locators.

HOW TO JUDGE THEM

1. *On precision, for low tolerance applications.* (Allen Dowel Pins are ground to a maximum microinch finish of 6 RMS protected by a rust preventive.)
2. *On strength, for shear resistance.* (Allen Dowel Pins are made from special Allenoy Steel, heat treated. Single shear strength measures from 160,000 to 180,000 psi.)
3. *On hardness of surface and a core hard enough to prevent "mushrooming" when driven into a tight hole.* (Allen Dowel Pins have a surface hardness of 62-64 Rockwell C Scale and core hardness of 52-54. Average case depth .010 to .020 depending on size.)

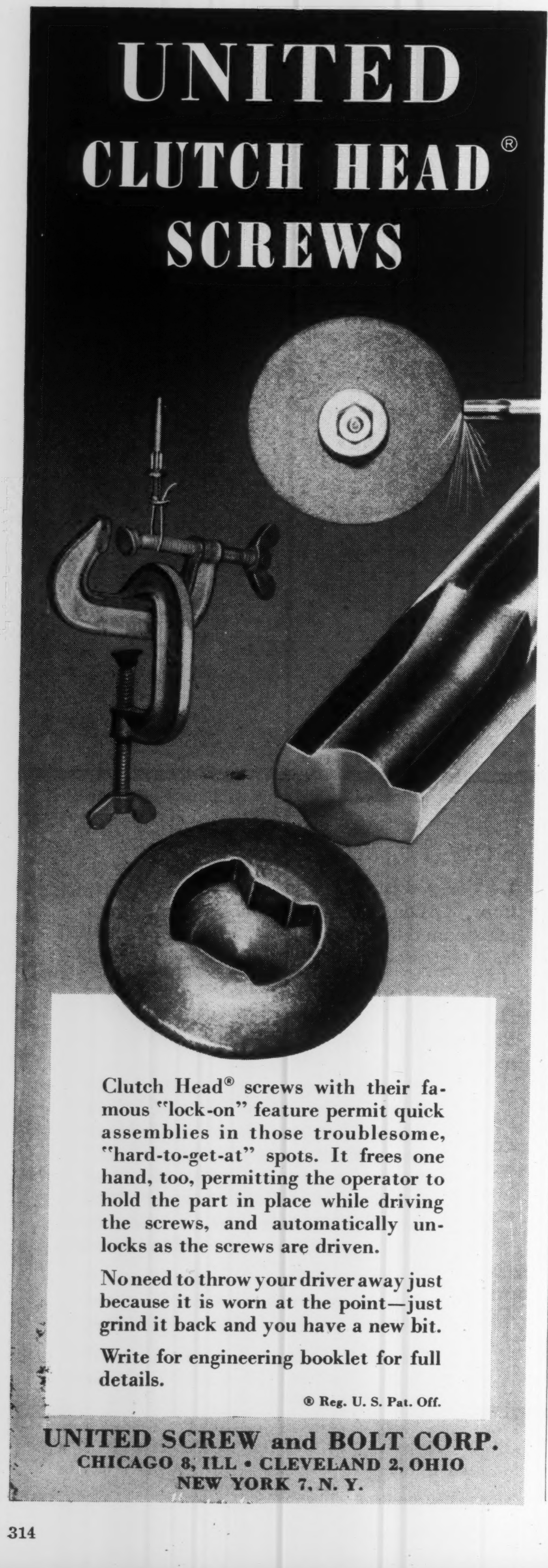
The simple sure way to be sure of uniformly superior dowel pin quality is the same as in buying precision socket screws — *get genuine Allens from your Industrial Distributor.* Only he sells them but *we will welcome your direct request for literature or application engineering assistance.*

ALLEN HEAD

ALLEN

MANUFACTURING COMPANY

Available in 108 Standard Sizes from $\frac{1}{8}''$ x $\frac{3}{8}''$ to 1″ x 6″. Standard tolerance .0002 oversize. Most sizes also standard in .001 oversize for repair work.


UNITED CLUTCH HEAD® SCREWS

Clutch Head® screws with their famous "lock-on" feature permit quick assemblies in those troublesome, "hard-to-get-at" spots. It frees one hand, too, permitting the operator to hold the part in place while driving the screws, and automatically unlocks as the screws are driven.

No need to throw your driver away just because it is worn at the point—just grind it back and you have a new bit.

Write for engineering booklet for full details.

® Reg. U. S. Pat. Off.

UNITED SCREW and BOLT CORP.
CHICAGO 8, ILL • CLEVELAND 2, OHIO
NEW YORK 7, N. Y.

circuits to minimize arcing. *Elwell-Parker Electric Co., Cleveland, O.*

Hydraulic Hoist: Electrically powered hydraulic hoist is rated at 5000 psi and provides power to lift a 1000-lb load 8 ft with built-in boom extension, a 1500-lb load 6½ ft, or a 2000-lb load more than 4 ft. Hoist is available with or without four-wheel floor truck. *Unit Mfg. Co., Minneapolis, Minn.*

Electric Truck: Model SX-24 Tractor Ox has 200 lb rated drawbar pull at 3¼ mph. No-load speed is 6¼ mph; with 10,000 lb rolling load, speed is 3¼ mph. Designed for stand-up operation, truck has four speeds forward and three reverse. Steering handle is mounted vertically directly over the center of drive unit and turntable. Handle bar extensions on each side of the steering column facilitate steering. Unit can turn in 39-in. intersecting aisles. *Barrett-Cravens Co., Northbrook, Ill.*

Hydraulic Lift: Model M266 manually-operated Presto hydraulic lift has pressure-controlled forks which are adjustable from 8 to 32 in. Forks are 26 in. long. Capacity of lift is 1000 lb. Lifting height is 66 in.; overall height of unit, 80 in. *Lee Engineering Co., Pawtucket, R. I.*

Metalworking

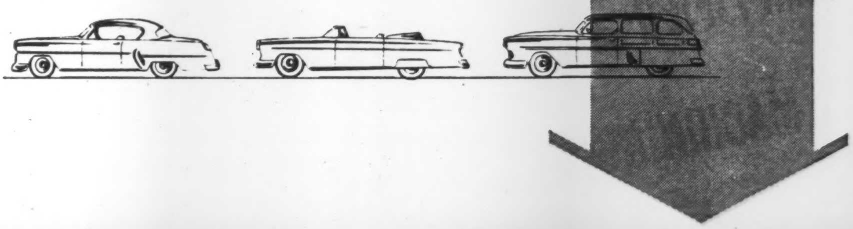
Precision Lathe: Sebastian 13-in. geared-head lathe has large, heavy bed, tapered-roller bearings supporting the spindle, and 1⅜-in. hole through the spindle. Multiple-splined spindle is thick walled, hardened and ground. All gears in headstock run in oil. Large enclosed gear box has 60 different pitches and feeds. Eight spindle speeds from 35-860 rpm are obtained with 1725 rpm drive motor, from 25-575 rpm with 1200 rpm motor; two-speed motor provides 16 speeds from 15-860 rpm. Cam-action tailstock clamp permits rapid shifting of tailstock. *Sheldon Machine Co. Inc., Chicago, Ill.*

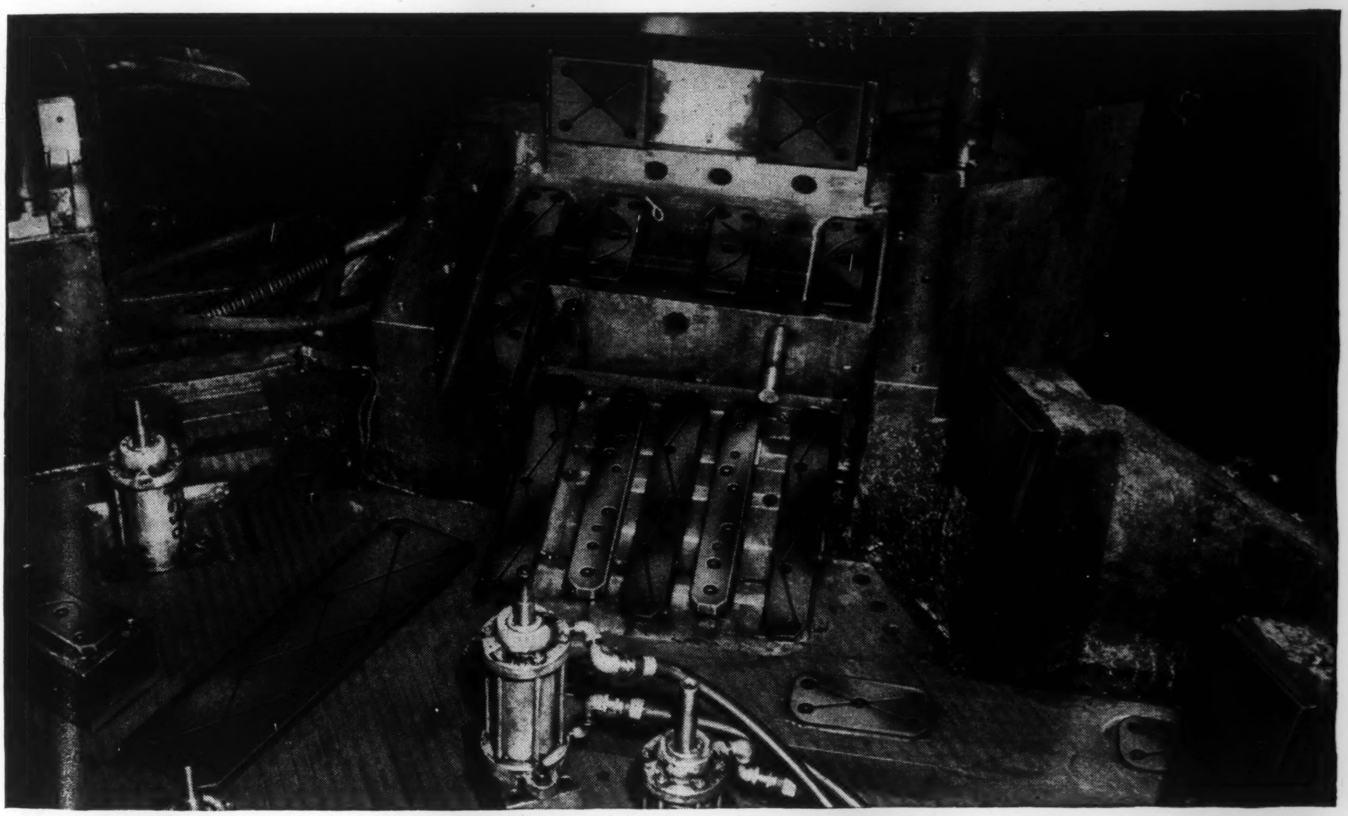
Bench Type Punch Press: Developed for short runs, 1-ton punch press is capable of 200 operations per minute. Single-pin clutch, operated by a hand lever, provides positive clutching action. Ram moves on machined ways, and a gib provides for take-up of wear. Punch is operated by direct V-belt drive from a ¼ to ½-hp motor. *Alva F. Allen, Clinton, Mo.*

Power Press Brake: Adaptable to most types of power brake press dies in short lengths up to and including 24 in., stub type power press brake performs forming operations requiring controlled pressure at the point of operation. Work cycle consists of low-pressure advance to the work and high-pressure forming or shaping. Stroke length is variable from 2 to 11 in., excluding die height. Unit's capacity is 42 tons at 100 psi. *Dayton Rogers Mfg. Co., Minneapolis, Minn.*

Vertical Universal Grinder: Hydraulically operated 42-in. grinder has normal maximum swing of 52 in. It does inside and outside diameter and angle cylindrical grinding. Machine grinds tapered or straight holes up to 2 ft deep; with the same setting of the

IT'S OK WHEN YOU FOLLOW THE LEADERS





The automotive industry stands as a leader in technological advancement and cost-cutting production techniques. That's why today practically every important automobile manufacturer is using Ohio Knife Aluminum Bronze Wear Plates on body dies.

By a unique clading process, long-wearing aluminum bronze is bonded to a machinable steel base. Cost is drastically lower when compared to solid cast bronze plates. A finer quality bearing surface is obtained, resulting in longer life. When fitting is required to suit die, steel backing of plate is easily machinable, and no difficulty is encountered drilling or counter boring through bronze surface. OK aluminum bronze plates are applicable wherever a die has a sliding or cam action. A large selection of OK aluminum bronze plates carried in stock . . . finished ground, flat and parallel . . . ready to ship. Specials made to your specifications. Literature available showing our standard sizes. Write Dept. 29-A.

Manufacturers for the metalworking industry of:

SLITTER KNIVES • SHEAR BLADES • BRONZE WAYS • ROTARY SHEAR KNIVES HARDENED SPACERS • BALL RACES • HARDENED WAYS • WEAR STRIPS • GIBS

THE OHIO KNIFE CO.

CINCINNATI 23, OHIO

PALMETTO® G-T® RING
MEANS SIMPLIFIED DESIGN
MEANS LESS MACHINING TIME
ASK BALDWIN!
CANNOT SPIRAL...
CANNOT EXTRUDE...

The Baldwin-Lima-Hamilton Corporation, Eddystone, Pa. Division, recognized a manufacturing advantage in the PALMETTO G-T Ring. Designing it into their Baldwin Compression Testing Machine (capacity—50,000 lb; pressure—1,000 psi; stroke—3 in.) meant design simplification—a simple groove instead of a complex stuffing box. Here is where engineering foresight paid off... Changing to this modern dynamic ram seal not only saved space, but hours of machining as well. Because high sealing efficiency and long service life are maintained along with these manufacturing advantages, the PALMETTO G-T Ring is now standard for Baldwin in this application.

The Palmetto G-T Ring, unlike an O-Ring, will not twist and turn in the groove. T-form prevents spiral failure even in dynamic applications.

Resilient "T"-section supported by non-extrusion rings on either side makes extrusion impossible. As pressure is applied, non-extrusion rings are urged against cylinder wall, blocking the path of extrusion.

Write for our Manual MP-200, Engineering Standards for Palmetto Molded Packings. For design information on G-T Rings, see our catalog in Sweet's Product Design File.

packing more performance into every application

PALMETTO Packings

GREENE, TWEED & CO. North Wales, Pa.

head, it grinds matching male parts. Head can be set at any angle up to 45 deg. Work spindle speeds range up to either 88 or 176 rpm in either direction. Grinding head has a stroke of 27½ in., with speeds up to 185 in. per minute. Maximum clearance over the face plate is 25 in.; over the work spindle, 30¾ in. Rapid traverse has speeds of up to 100 in. per minute. Wheel spindle motor speed is 3600 rpm. *Springfield Machine Tool Co., Springfield, O.*

Punch Press: Model 7, a 7½-ton power press, has one-piece crankshaft with flywheel mounted on two roller bearings. Ram and ram guide are 90-deg, V type and are extra long to ensure precise operation. Standard stroke is 1½ in.; strokes up to 3 in. are optionally available. Shut height is 7¾ in. to the bolster bed, adjustment up, ram down. Bolster plate is 7½ x 11 x 1 in. thick. *Kenco Mfg. Co., Los Angeles, Calif.*

Milling Machine: Workpieces measuring up to 30 x 48 in. and weighing 5000 lb can be bored, drilled or vertical milled on the Electromill. Machine has 35-in. throat capacity. Both spindle speed and feed can be changed without stopping the spindle. All controls are located in a panel that can be moved to the most convenient position. *W. B. Knight Machinery Co., St. Louis, Mo.*

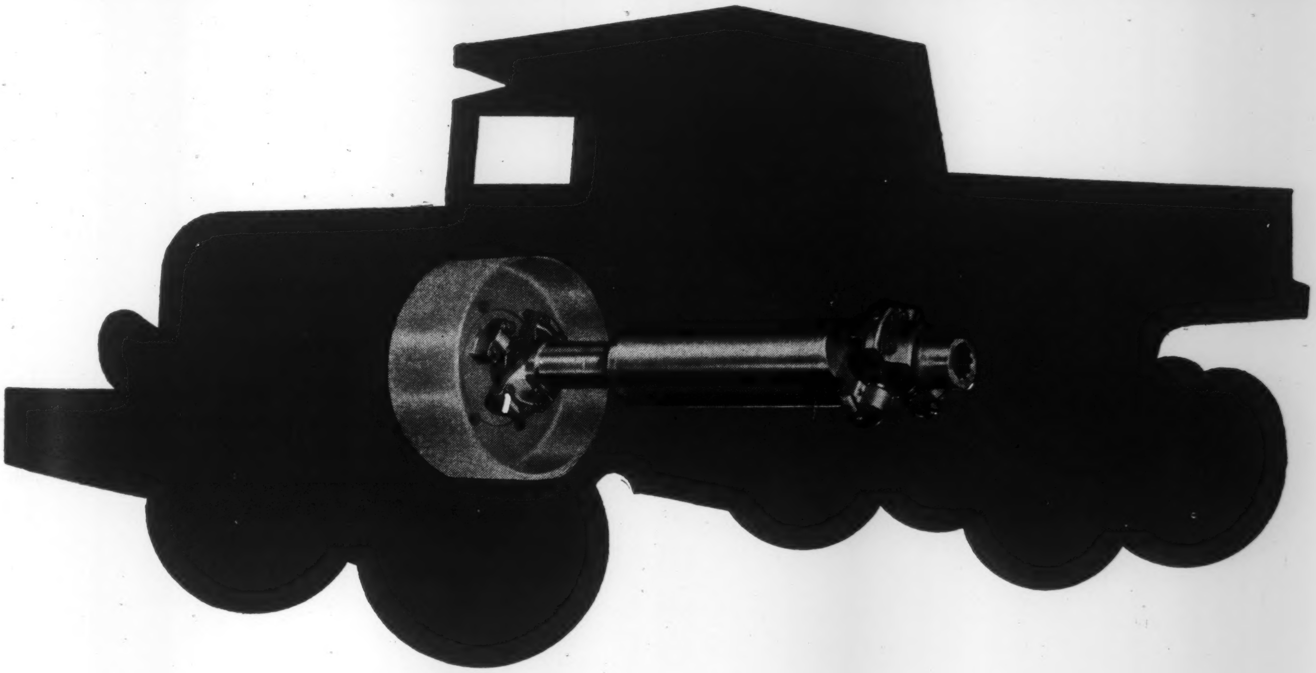
Press Brakes: Line of 50 to 775-ton press brakes perform forming, bending, punching, blanking and related operations. Uniform bends are assured by constant application of power from double-end twin drives with double-reduction gearing which is totally enclosed in sealed oil baths. Machines have laminated nonmetallic ways. *Niagara Machine & Tool Works, Buffalo, N. Y.*

Universal Grinder: Work head, wheel head and table of Cresta grinder are completely universal, permitting taper or straight work on either outside or inside-diameter grinding. Conversion is accomplished in seconds' time. Machine has a 10 x 1 x 3-in. wheel powered by a two-speed 1¼-hp motor. Work head operating at speeds from 125 to 610 rpm, accommodates live or dead centers, a 4-in. three-jaw chuck, or 9/16-in. capacity quick-change collets. Work capacity is 4 x 10 in.; recommended work diameter for production grinding is 2 in. Grinder measures 34 x 44 in. *American Herforder Corp., Chicago, Ill.*

Office Machines

Automatic Calculator: Ten-key adding machine has keyboard so arranged that the cipher bar is directly under the thumb or little finger, depending upon which hand is used. All keys are large, and the 4, 5 and 6-keys in the center horizontal row are cupped to facilitate touch operation. A small window directly above the keys indicates each item as it is entered into the machine and before it is printed or added. A true credit balance, whether positive or negative, is printed from one depression of the Total key; a clear signal is printed automatically with the first item following a total; and negative values are printed in red, with the proper symbol. Machine has

RUGGED

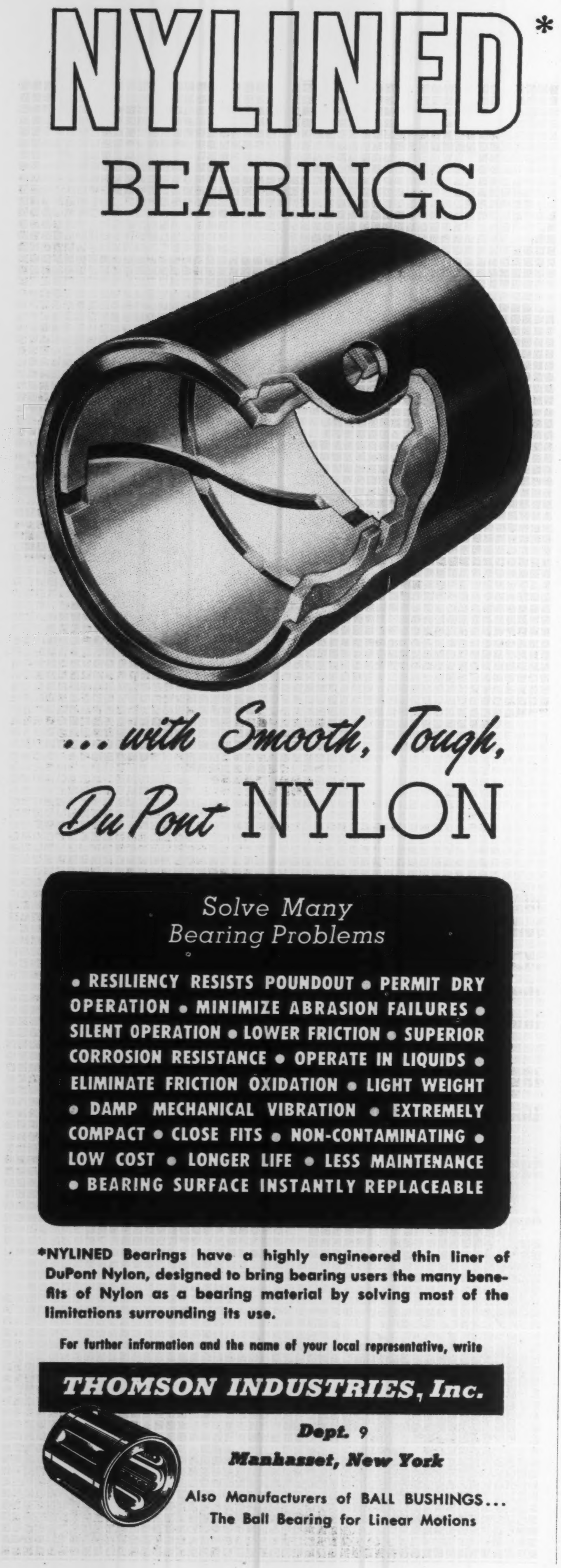


Because MECHANICS Roller Bearing UNIVERSAL JOINTS drive through KEYS—instead of bolts—they stand up under punishment that shears off other types of fasteners. They are designed with less parts and connections for easy assembly and servicing — smooth running balance — maximum strength with less weight — and long, trouble-free, safe operation. Rugged stamina is just one of the advantages you get when you specify MECHANICS Roller Bearing UNIVERSAL JOINTS. Let MECHANICS engineers help you design this and other competitive sales features into your product's transmission train.

MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner • 2032 Harrison Ave., Rockford, Ill.

MECHANICS
Roller Bearing
UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment



NYLINED*
BEARINGS

...with Smooth, Tough, DuPont NYLON

Solve Many Bearing Problems

• RESILIENCY RESISTS POUNDOUT • PERMIT DRY OPERATION • MINIMIZE ABRASION FAILURES • SILENT OPERATION • LOWER FRICTION • SUPERIOR CORROSION RESISTANCE • OPERATE IN LIQUIDS • ELIMINATE FRICTION OXIDATION • LIGHT WEIGHT • DAMP MECHANICAL VIBRATION • EXTREMELY COMPACT • CLOSE FITS • NON-CONTAMINATING • LOW COST • LONGER LIFE • LESS MAINTENANCE • BEARING SURFACE INSTANTLY REPLACEABLE

*NYLINED Bearings have a highly engineered thin liner of DuPont Nylon, designed to bring bearing users the many benefits of Nylon as a bearing material by solving most of the limitations surrounding its use.

For further information and the name of your local representative, write

THOMSON INDUSTRIES, Inc.
Dept. 9
Manhasset, New York

Also Manufacturers of BALL BUSHINGS...
The Ball Bearing for Linear Motions

enclosed paper roll that lifts out for replacement, hand grips for portability, rotary printing mechanism for quiet operation and transparent paper tearing blade. *Friden Calculating Machine Co. Inc., San Leandro, Calif.*

Accounting Machine: Class 34 machine can be used for accounts receivable, accounts payable, payroll, inventory records, general ledger and any other bookkeeping procedures applicable to an accounting machine. It has a hydraulically operated carriage and a system of automatic control through detachable "form bars" which may be switched rapidly to change from one bookkeeping job to another. Machine can subtract directly from every total, can clear all totals automatically and has a reverse key which permits immediate correction of errors. Carriage functions are fully automatic. Machine has five totals. Available in both typewriter and nontypewriter models; typewriter model has standard keyboard, electric typewriter. *National Cash Register Co., Dayton, O.*

Packaging

Automatic Stapler: Model OTC automatic stapling machine staples hinged or unhinged lids on octagon-shaped cartons which have open square centers. It handles cartons measuring 26 to 54 in. across the outside flats, with 6 to 20-in. square inside openings and varying in height from 3/8-in. to 2 in. Machine has three adjustable stapling heads. Staple pattern for the heads is staggered to minimize stops and indexing operation. Change-over time from a run of one size cartons to another is approximately 2 minutes. *International Staple and Machine Co., Herrin, Ill.*

Heat Sealer: Semi-automatic Comet 54 machine seals coated or laminated barrier materials to government specifications. Automatic tripping device controls heat sealing cycle after simple preliminary handknob settings for time, temperature and pressure. Integral stop and adjustment permits seal width from 1/4-in. to 1 in. Maximum length of a single seal is 13 1/2 in. O-ring sealed air piston provides uniform pressure throughout seal area. Integral controls include on and off switch, air pressure regulator to control sealing bar pressure, preset dwell timer adjustable from 1 to 15 seconds in 1/4-second increments, and an adjustable thermostat control to regulate heater bar. Heater bar is coated with Teflon to prevent sticking of vinyl or polyethylene sealing materials. All wiring, pressure tubing and moving parts are totally enclosed. *Fox Hills Tool and Die Co., Culver City, Calif.*

Plant Equipment

Portable Filtration Unit: Caster-mounted filtration unit, incorporating Delpark disposable belt type filter, is easily transported for periodic filtration of various liquids and oils which do not require continuous filtration. Unit utilizes various filter media for numerous filtration requirements and may be used on quenching oils, cutting oils, coolants, hydraulic oils, test stand

Why you can *lower inspection costs*

with a Kodak Conju-Gage Gear Checker

Why the composite check

The composite check recommended in American Standard B6.11-1951 tests gears functionally by running the gear against a master of known accuracy. The resulting displacement shows at once the cumulative effect of as many as six types of error—eliminates time-consuming checks for each individual error. The check is rapid and conclusive.

Why the Kodak Conju-Gage Gear Checker

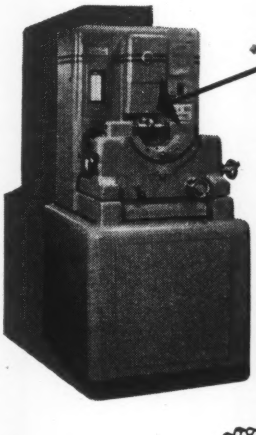
To meet today's tolerance requirements, the Kodak Conju-Gage Gear Checker uses a master made with a new order of precision. This is the Kodak Conju-Gage Worm Section, produced by thread grinding under control of a precision lead screw.

The accuracy inherent in this method means every right gear is passed by the worm section, reducing rejection losses. The transverse curvature produced by this method provides a master that can be used to check any gear of like pitch and pressure angle, regardless of helix.

Not only can a single worm section be used in place of a number of circular masters, but such a worm section can be reground to specification as often as necessary—at a fraction of replacement cost. It is easily checked for accuracy by familiar toolroom procedures.

You can find out more about the economies possible through Kodak Conju-Gage Instrumentation by sending for a copy of the booklet, "Kodak Conju-Gage Gear Testing Principle." Write to:

Special Products Sales Division
EASTMAN KODAK COMPANY
Rochester 4, N. Y.



The Kodak Conju-Gage Gear Checker automatically records the composite effects of runout, base pitch error, tooth thickness variations, profile error, lead error, and lateral runout. Illustrated is the Kodak Conju-Gage Gear Checker, Model 4U, for gears up to 4⅛" pitch diameter. Larger and smaller models are also available.

CONJU-GAGE INSTRUMENTATION

...a new way to check gear precision in action

To inspect all kinds of complex parts on a bright screen, Kodak also makes two highly versatile contour projectors.

Kodak